EVALUATION, MEASUREMENT & VERIFICATION OF CPS ENERGY'S FY 2017 DSM PROGRAMS

May 1, 2017

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1. EXECUTIVE SUMMARY

CPS Energy retained Frontier Associates ("Frontier") to conduct a comprehensive and independent evaluation, measurement, and verification (EM&V) of CPS Energy's Fiscal Year (FY) 2017[1] demand side management (DSM) programs. This report describes the EM&V methodology and process and presents the findings of the evaluation.

The evaluation focused primarily on calculating the energy and demand savings achieved by CPS Energy's FY 2017 DSM programs on an annualized basis. Additionally, the evaluation reviewed program expenditures to calculate program cost-effectiveness and recommended enhancements to program design and implementation for CPS Energy's consideration.

The FY 2017 program suite differed from that of the previous years in several ways which uniquely affected this year's analysis. Primarily, CPS Energy contracted with two implementers to transition implementation of some residential and commercial programs from CPS Energy to the implementer during the latter half of calendar year 2016, as shown in the figure below.

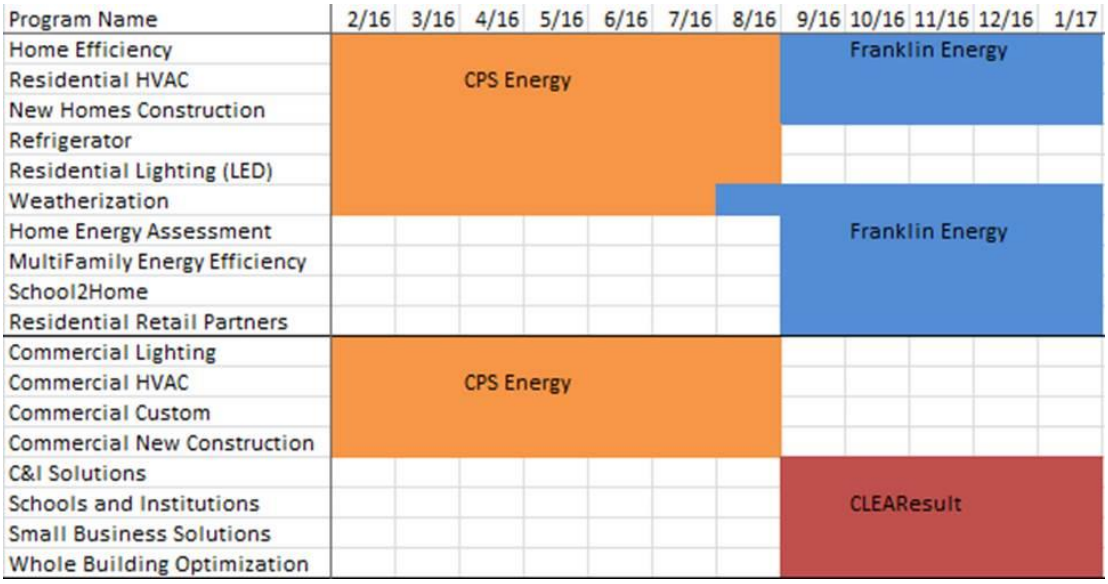

Figure 1-1: Programs by Implementer

In some cases, programs, eligible measures, and incentives offered remained essentially unchanged through the program year, even as responsibility for implementation shifted to the contracted implementer. For these programs, Frontier separately gathered information on the costs and energy savings achieved by the program as implemented by CPS Energy and the contractor, but reported costs, savings, and cost effectiveness achieved as a single program.

[1] FY 2017 began on February 1, 2016 and extended through January 31, 2017. This report encompasses all DSM program activity accounted for by CPS Energy within this time period.

In other cases, where contractor-implemented programs were entirely new, offered significantly different approaches to addressing targeted markets, or offered significantly different incentives or sets of eligible energy efficiency measures, the programs were reported separately.

In these cases, program costs reported herein may include extra costs associated with startup, and energy savings and benefits may be lower than expected due to lower levels of participation in the early ramping stage of program implementation. Benefit-cost results reported here should be interpreted within this context. Future evaluations are planned to cover full contractual and fiscal years, and should yield results that are more directly comparable with past evaluations.

Additionally, for the FY 2017 evaluation, Frontier formalized evaluation standards by publishing and sharing with CPS Energy and its contracted implementers a Technical Guidebook for Energy Efficiency and Demand Response Programs. The *CPS Energy Guidebook* provides a single common reference for estimating energy and peak demand savings resulting from the installation or implementation of energy efficiency and demand response measures provided through CPS Energy's programs, and contains a compilation of deemed savings values for use in savings estimation. The methodologies described by and used in the Guidebook to obtain deemed savings values are based on the Public Utility Commission of Texas' (PUCT) Technical Reference Manual (TRM), with certain modifications required to accommodate CPS Energy's weather zone and STEP program goals and metrics. The *Guidebook* is intended to be updated annually to provide a common reference to Frontier's evaluation methodology.

In all, this year's report summarizes Frontier's evaluation of 27 different energy efficiency programs offered by CPS Energy during FY 2017. Table 1-1 lists all evaluated programs.

Table 1-1. Programs Evaluated in FY 2017

Program Group	Program Name
Residential	Home Efficiency
	Residential HVAC
	New Homes Construction
	Refrigerator
	Residential Lighting (LED)
	Weatherization
	Home Energy Assessment
	MultiFamily Energy Efficiency
	School2Home
	Residential Retail Partners
Commercial	Commercial Lighting
	Commercial HVAC
	Commercial Custom
	Commercial New Construction
	C&I Solutions
	Schools and Institutions
	Small Business Solutions
	Whole Building Optimization

Program Group	Program Name
Demand Response	Commercial Demand Response
	Auto Demand Response
	Smart Thermostat
	Home Manager
	Bring Your Own Thermostat
Solar	Solar Initiative - Residential
	Solar Initiative – Comm. & Schools
	SolarHostSA Pilot
	Roofless Solar Pilot

1.1 SUMMARY OF ENERGY AND DEMAND IMPACTS

Net energy and demand savings are listed in Table 1-2. The savings are represented on an annualized basis in order to simplify the reporting structure and for easy comparison from year to year.

Table 1-2: FY 2017 Net Energy and Demand Savings

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Energy Efficiency Programs									
Home Efficiency	93%	2,105,647	964	2,012	806	$677,978	$21,245	$699,223	3.55
Residential HVAC	95%	11,816,563	5,140	5,277	4,449	$4,070,510	$106,443	$4,176,953	2.88
New Homes Construction	100%	440,324	256	379	308	$468,832	$12,127	$480,959	1.54
Refrigerators	63%	212,893	28	32	29	$56,570	$8,171	$64,741	1.00
Residential Lighting (LED)	85%	87,354	9	43	14	$63,647	$3,404	$67,051	0.79
Weatherization	100%	15,211,611	7,279	15,661	6,936	$18,005,102	$2,125,699	$20,130,801	0.92
Home Energy Assessment	84%	1,584,885	142	627	199	$944,227	$16,354	$960,581	0.81
MultiFamily Energy Efficiency	92%	1,011,265	85	341	108	$352,793	$6,110	$358,903	1.19
School2Home	95%	1,265,003	100	383	119	$547,602	$9,485	$557,087	0.86
Residential Retail Partners	77%	1,263,511	127	628	199	$321,825	$5,574	$327,399	2.35
Residential Subtotal		34,999,056	14,129	25,382	13,167	$25,509,086	$2,314,612	$27,823,698	1.31
Commercial Large Lighting	85%	116,062,320	19,240	21,230	19,151	$18,192,066	$636,929	$18,828,995	3.29
Commercial HVAC	96%	10,428,666	2,715	2,856	2,614	$3,894,956	$147,008	$4,041,964	2.44
Commercial Custom	100%	7,678,459	391	513	354	$664,742	$29,264	$694,006	2.77
Commercial New Construction	100%	8,016,167	1,159	1,183	1,133	$1,061,486	$30,462	$1,091,948	4.61
C&I Solutions	85%	1,536,628	337	390	335	$923,734	$17,671	$941,405	0.99
Schools & Institutions	100%	0	0	0	0	$628,549	$12,024	$640,573	0.00
Small Business Solutions	85%	324,767	13	82	13	$411,674	$7,875	$419,549	0.28
Whole Building Optimization	100%	0	0	0	0	$155,089	$2,967	$158,056	0.00
Commercial Subtotal		144,047,006	23,856	26,255	23,600	$25,932,297	$884,200	$26,816,497	2.97
Energy Efficiency Subtotal		179,046,063	37,986	51,637	36,767	$51,441,383	$3,198,812	$54,640,195	2.13

Table continues on the next page.

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Rebate $	Admin and Marketing $	Total Program $	Program Administrator Benefit-Cost Ratio
Demand Response Programs*									
Commercial Demand Response	100%	2,625,434	81,507	97,039	66,121	$4,700,074	$167,113	$4,867,187	2.46
Auto Demand Response	100%	149,111	6,189	7,290	5,633	$1,286,639	$52,868	$1,339,507	1.52
Smart Thermostat	100%	740,707	34,757	43,863	30,041	$3,966,166	$168,578	$4,134,744	1.72
Home Manager	100%	504,961	40,170	45,703	36,235	$3,340,585	$193,131	$3,533,717	1.51
Bring Your Own Thermostat	100%	3,653,236	10,928	13,197	10,441	$963,456	$118,104	$1,081,560	3.05
Demand Response Subtotal		7,673,449	173,550	207,091	148,471	$14,256,920	$699,794	$14,956,714	2.20
Renewable Energy Programs									
Solar Initiative - Residential	100%	47,800,667	13,741	28,328	12,367	$35,345,295	$1,442,717	$36,788,012	1.46
Solar Initiative - Commercial & Schools	100%	3,638,996	1,094	2,164	953	$3,125,011	$128,431	$3,253,442	1.28
SolarHostSA Pilot**	100%	1,984,985	571	1,176	514	$0	$78,323	$78,323	0.50
Roofless Solar Pilot	100%	2,159,271	576	1,133	0	$1,289,375	$126,326	$1,415,701	0.83
Renewable Energy Subtotal		55,583,919	15,982	32,802	13,834	$39,759,682	$1,775,797	$41,535,479	1.41
Grand Total		242,303,430	227,518	291,530	199,072	$105,457,985	$5,674,403	$111,132,387	1.86

* The PACT for Demand Response Programs is calculated based on the net present value of avoided cost benefits divided by the net present value of program costs *attributable to new, incremental participants during the program year.* Because total program costs in the table represent the costs attributable to all participants, the PACT for Demand Response Programs cannot be directly calculated from data presented in the table.

** In calculating the PACT for the SolarHostSA Pilot program, Frontier considered bill credits paid to host site customers as incentives. This differs from CPS Energy's accounting, which shows $0 in rebates paid to customers. Thus, the PACT for the SolarHostSA Pilot program cannot be directly calculated from the data presented in the table.

Additional table notes:

- Net savings = gross savings * Net to Gross ratio / (1 – line loss factor).
- Demand response program net energy and demand savings (in lighter shade) represent end of year program capability, based on end of year enrollment.
- All residential and commercial energy efficiency programs were involved in a transition during FY 2017, transitioning to a different implementer, shutting down, or starting up during the year. Savings and benefit cost calculations should be interpreted in the context of these transitions.

1.2 CUMULATIVE PROGRESS TOWARD MEETING STEP GOALS

CPS Energy's Save for Tomorrow Energy Plan (STEP) is an energy conservation program that aims to save 771 MW of electricity between 2009 and 2020. At the end of FY 2017, Frontier determined that CPS Energy had accomplished 522 MW of cumulative demand savings since the program's inception. CPS Energy's cumulative progress toward meeting STEP goals is shown in Figure 1-2.

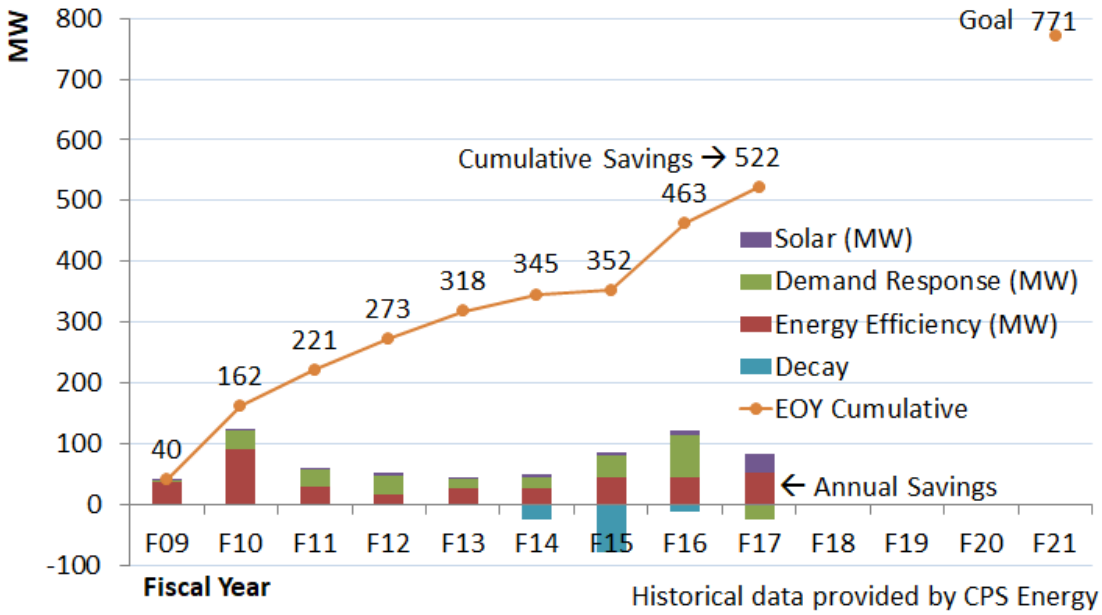

Figure 1-2: Cumulative Progress toward Meeting STEP Goal

1.3 SUMMARY OF ECONOMIC IMPACTS

Frontier's evaluation included collecting administrative, management, and marketing costs as well as total incentives paid. The following economic impact metrics were calculated:

- Cost of Saved Energy (CSE), which represents the levelized program cost per annual kWh saved, was $0.0500.
- Net Reduction in Revenue Requirements (RRR), which represents the net reduction in utility costs due to the impact of the energy efficiency improvements, was $94,261,200.
- Benefit-Cost Ratio, representing the output of the program administrator cost test, was 1.86.
- For Demand Response (DR) programs, the summary table includes estimated savings from all active participants as of the end of FY 2017, including those who signed up in previous years, as this most accurately represents DR program capabilities in FY 2017 and beyond.

For DR program benefit-cost calculations, Frontier analyzed only the cohort of participants added in FY 2017. This approach is consistent with other program benefit-cost calculations, but caution is advised when comparing DR results to benefit-cost calculations from prior years. This is especially the case where there are significant differences between cohorts from FY 2017 and other years, since significant differences in the composition of cohorts from year to year affect the outcome.

2. EVALUATION METHODS

2.1 ENERGY IMPACTS

Frontier's approach to this evaluation has been to leverage existing EM&V work previously conducted for CPS Energy and other electric utilities in Texas. For the past fifteen years, investor-owned utilities, EM&V consultants, and stakeholder groups have collaborated to develop accurate and comprehensive "deemed" savings for hundreds of residential and commercial energy efficiency measures, under the auspices of the Public Utility Commission of Texas (PUCT). This extended effort has culminated in the publication of the *Texas Technical Reference Manual* (Texas TRM),[2] a compendium of algorithms, baseline efficiency data, efficiency standards, energy savings calculations and data tables. Frontier has adapted the Texas TRM to be applicable to CPS Energy's service territory and can provide CPS Energy with energy and demand impact estimates that have been vetted numerous times by independent third parties, and are consistent with impact estimates being used by all of the investor-owned utilities in Texas. The adapted Texas TRM, along with other measures required for CPS Energy programs, can be found in the *CPS Energy Guidebook*. For this analysis, the *CPS Energy Guidebook* dated October 2016 was used except where noted.

2.2 PEAK DEMAND IMPACTS

To calculate coincident peak demand savings, Frontier employed a probabilistic analysis using San Antonio TMY3 hourly weather data.[3] This approach relates actual historical weather data for San Antonio, day-of-week, and time-of-day variables to Electric Reliability Council of Texas (ERCOT) zonal peak conditions. Those historical relationships are then applied to TMY3 hourly weather data to estimate the hours in a TMY data file most likely to coincide with hours of high demand in ERCOT's CPS Energy-San Antonio zone. To determine hours of highest demand in this zone, Frontier used ERCOT data and added back in demand savings attributable to DR deployments. Estimates of the impacts of various energy efficiency measures during the top twenty hours associated with high demand in the TMY data are identified, and the probability-weighted estimate of an energy efficiency measure's demand savings during those peak hours is then calculated. This approach has been adopted for use in the Texas TRM v. 3.1, used by all investor-owned electric utilities beginning in 2016.

Based on Frontier's analysis, the hours presented in Table 2-1 have the highest probability of occurring during CPS Energy's peak (listed in order of probability, from highest to lowest). Additional hours are shown because some hours, such as those occurring on weekends or holidays, are eliminated for some measures.

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[2] Public Utility Commission of Texas (PUCT) Technical Reference Manual (TRM) v. 2.1. Available for download at: http://texasefficiency.com/index.php/regulatory-filings/deemed-savings

[3] Typical Meteorological Year (TMY) are data sets of hourly values of solar radiation and meteorological elements for a 1-year period. TMY3 is the most recent version of this data. Data collected at the Kelly Field Air Force Base (Kelly AFB) station were generally used, since the temperature data series collected at the San Antonio International Airport is inexplicably higher than the readings collected at other local weather stations. (See Itron, CPS Energy June 2014 Electricity Forecast, Sept. 2014, pp. 8-9.)

Table 2-1: Top Hours from Probabilistic Analysis

Month	Day	Hour (start)	Temp (°F)	Peak Probability (with DR addback)
6	19	15	104	0.939953
6	19	16	102.92	0.923473
6	20	16	102.92	0.923473
6	20	15	101.84	0.627406
6	19	14	102.92	0.600033
6	20	14	102.92	0.600033
6	19	17	100.94	0.411083
6	10	15	100.94	0.399418
6	18	15	100.94	0.399418
6	10	16	99.86	0.338925
7	31	15	102.02	0.311633
8	20	15	99.86	0.282339
8	19	16	98.96	0.267512
8	20	16	98.96	0.267512
8	17	15	98.96	0.134484
7	31	16	100.04	0.121139
8	18	16	97.88	0.106969
6	20	17	98.96	0.082923
6	17	15	98.96	0.079315
6	12	16	97.88	0.062276
6	16	16	97.88	0.062276
6	17	16	97.88	0.062276
6	18	16	97.88	0.062276
6	10	14	99.86	0.059918
6	18	14	99.86	0.059918
8	18	15	97.88	0.048491
8	19	15	97.88	0.048491
8	17	16	96.98	0.045171
8	23	16	96.98	0.045171
8	20	14	98.96	0.043431
8	23	14	98.96	0.043431
7	30	16	98.96	0.043252
7	31	14	100.94	0.041583
6	17	17	97.88	0.028802
6	18	17	97.88	0.028802
6	13	15	97.88	0.027479
6	14	15	97.88	0.027479
6	21	15	97.88	0.027479
6	5	16	96.98	0.025559

Month	Day	Hour (start)	Temp (°F)	Peak Probability (with DR addback)
6	11	16	96.98	0.025559
6	13	16	96.98	0.025559
6	21	16	96.98	0.025559
6	17	14	98.96	0.024555
8	18	17	96.98	0.020688
8	19	17	96.98	0.020688
8	20	17	96.98	0.020688
7	31	17	98.96	0.019788
7	30	14	100.04	0.016847
8	7	16	95.9	0.015279
8	28	16	95.9	0.015279

The estimated coincident peak savings is the probability-weighted average of the kW in the top twenty applicable time periods for each measure. This approach was used for all measures, except where noted.

2.3 NET IMPACTS

To derive net impacts, Frontier utilized Net-to-Gross (NTG) ratios provided by CPS Energy. Separate line loss factors relating to energy and demand are based on a 2016 energy system loss study provided by CPS Energy. The line loss factors were applied to the gross energy and peak demand impacts for each measure.

2.4 AVOIDED COST BENEFITS

2.4.1 Avoided Capacity and Energy

Avoided cost benefits were calculated using CPS Energy-provided avoided energy and capacity costs, and CPS Energy's standard discount rate. For this year's analysis, CPS Energy provided avoided energy costs as the nominal $/MWh of the marginal variable cost of production using the load forecast without STEP programs being funded beyond February 1, 2017. The Estimated Useful Life (EUL) values from the Texas TRM were utilized for all STEP measures, except where noted. For the purpose of calculating avoided energy benefits, annual kWh were allocated into the following time periods, based on season, day of the week, and hour of the day.

- Summer On-Peak
- Summer Mid-Peak
- Summer Off-Peak
- Non-Summer Mid-Peak
- Non-Summer Off-Peak

Frontier developed or adopted appropriate 8760-hour load shapes for each STEP measure, in order to assign annual kWh to the appropriate cost periods.

Avoided capacity costs (nominal $/kW-yr) were developed for on-peak and off-peak STEP measures. On-peak avoided capacity cost was defined as the forecasted capital and fixed operation & maintenance cost of an LMS100 natural gas combustion turbine (NGCT) plant, annuitized over 35 years. Off-peak avoided capacity cost was defined as the blended cost of CPS Energy's forecasted capital and fixed operation & maintenance cost of an LMS100 NGCT and an SGT6-5000 natural gas combined cycle (NGCC) or GE 7F.05 "Flex" NGCC, depending on time frame; with the blending ratio defined as the ratio of the added NGCC/NGCT capacity in CPS Energy's 25-year expansion plan.

2.4.2 Avoided Transmission Cost of Service (ERCOT 4CP TCOS)

ERCOT recovers the costs of transmission incurred by transmission service providers via a charge on load-serving entities, including CPS Energy. The charge is allocated to load-serving entities based on each entity's average demand during four ERCOT system peaks (known as four "coincident peaks," or "4CP events") from June to September each year. To minimize this charge, CPS Energy anticipates likely 4CP events and deploys demand response resources to reduce demand accordingly. Energy efficiency measures also contribute to demand reduction during 4CP events.

To estimate gross demand reduction during FY 2017 4CP events within each demand response program/subprogram we multiplied the estimated load reduction per participant by the number of active participants and a "deployment success rate," the rate at which CPS Energy correctly anticipated and deployed each resource during FY 2017 4CP events.

For energy efficiency and renewable energy programs, we used hourly load shapes for each program measure to estimate the impacts during 4CP event hours for each weekday during the months of June through September. These monthly impacts were then averaged to estimate the 4CP impact for each program.

The total reduction to 4CP demand is then valued at the expected future TCOS provided by CPS Energy.

2.4.3 Avoided Price Spikes Savings (kWh)

Another potential benefit of demand response programs derives from avoiding intervals of especially high energy prices in the ERCOT market. In ERCOT energy prices may go up to $9,000/MWh ($9/kWh), which is over 200 times the average wholesale price of energy from 2010-2014. By reducing demand during price spikes, CPS Energy can benefit by avoiding high prices for energy it needs, or by selling energy from its own or contracted generation sources into the market. As Demand Response (DR) programs are sometimes able to be deployed in anticipation of price spike events, avoided price spike savings were only calculated for DR programs.

Price spikes in the ERCOT market have a number of causes, occur irregularly, and are hard to predict. ERCOT prices hit peaks 68 times in CPS Energy's load zone during 2011, but only 7 times in the combined five years that followed.[4] Price spikes are also harder to react to in a timely manner with some demand response resources. For example, Nest thermostats in the Nest Rush Hour Rewards program require day-ahead notice to the program implementer, which makes rapid response to an unexpected price spike event impossible.

To estimate the value of energy (kWh) saved during FY 2017 price spike events, we compiled energy savings from all DR programs for every interval such programs were deployed, and multiplied the sum within each interval by the corresponding ERCOT load zone energy price less CPS Energy's avoided cost of energy during the summer peak period. This method estimates the value of energy savings achieved during DR events without double counting the value of avoided energy costs.

2.5 ECONOMIC ANALYSIS

The following cost-effectiveness metrics were calculated for CPS Energy's programs:

Program Administrator Benefit-Cost Ratio. This is the ratio of the net present value (NPV) of avoided energy and capacity benefit, divided by the program's incentives and administrative costs, expressed as:

$$Benefit\ Cost\ Ratio = \frac{NPV\ of\ avoided\ cost\ benefit}{Program\ incentives + Admin\ Costs}$$

Cost of Saved Energy. The Cost of Saved Energy (CSE) is the cost per kWh of energy efficiency and/or demand response program impact. The CSE is the ratio of the levelized program costs divided by the annual energy kWh savings. Levelized program costs are calculated using a Capital Recovery Factor (CRF), which incorporates the estimated useful life (EUL) of the savings (weighted by measure) and an annual discount rate.

$$CSE = \frac{Levelized\ Program\ Costs}{Annual\ kWh\ savings}$$

Net Avoided Cost Benefit. The net reduction in utility costs from the energy and demand saved by CPS Energy's programs, calculated as the avoided cost benefit minus the total Program costs.

[4] In this example, we define peak as a price of $3,000, the highest price allowed under ERCOT market rules prior to 2015.

3. RESIDENTIAL PROGRAMS

3.1 SUMMARY OF RESIDENTIAL IMPACTS

CPS Energy offered the following energy efficiency programs for the residential sector in FY 2017:

- Home Efficiency - targets a wide range of energy efficiency measures that save cooling and heating energy in existing homes.
- Residential HVAC - offers incentives for the purchase of eligible high efficiency central air conditioners, heat pumps and room air conditioners.
- New Homes Construction - offers incentives to developers to build at least 15% more energy efficient than current CoSA building codes.
- Refrigerators - offers incentives to homeowners to recycle old/extra refrigerators and freezers to remove inefficient appliances from use.
- Residential Lighting (LED) - CPS Energy is beginning the transition from CFL to the more efficient LED as the cost of light emitting diodes and related technology become financially feasible as an energy efficiency measure.
- Weatherization - assistance program designed to help families in need reduce their monthly utility bills. Eligible participants, whether they are homeowners or renters, may receive free weatherization upgrades designed to increase the energy efficiency of their homes.
- Home Energy Assessment - a free in-person assessment that helps customers identify energy saving opportunities in their home, which may include LED lighting being directly installed during the home visit.
- MultiFamily Energy Efficiency - engages the multi-family segment with multiple direct install measures to help save energy through, for example, upgrading lighting with LED lights and other energy saving opportunities.
- School2Home - incorporates energy efficiency into the 6th grade classroom by equipping teachers, students and parents with in-class curriculum and take home kits full of energy efficient products.
- Residential Retail Partners - offers point of purchase incentives on ENERGY STAR lighting and room air conditioners at participating retailers.

CPS Energy's portfolio of residential programs addresses all markets and major residential end uses (residential demand response programs are included in Section 5).

To evaluate energy impacts for most program measures, Frontier utilized the current version of the *CPS Energy Guidebook*. For programs or measures where other methods were used, those are referenced in each section.

It should be noted that for some envelope measures, the non-coincident peak occurs during the non-summer months, since a significant number of measures were installed on homes with electric heating.

The contribution of each residential program to the portfolio's energy, peak demand, and non-coincident peak savings are shown in the following figures.

All values in the tables and charts throughout this section represent energy and demand savings from new FY 2017 program participants as measured at the participant or end-user level. These savings are adjusted in the program portfolio rollup table in the Executive Summary and in benefit-cost calculations to account for net-to-gross ratios and line losses.[5]

Some programs were implemented under contract to CPS Energy and started more than halfway through CPS Energy's fiscal year. As such, program costs reported herein may include extra costs associated with startup, and energy savings and benefits may be lower than expected due to lower levels of participation in the early ramping stage of program implementation. Benefit-cost results reported here should be interpreted within this context. Future evaluations are planned to cover full contractual and fiscal years, and which should yield results that are more directly comparable with past evaluations.

[5] Net-to-gross (NTG) ratios are estimated at the level of individual programs, and account for the net effects of free ridership and spillover. Free riders are defined as customers who would have delivered energy or demand savings without any program incentives but who received a financial incentive or rebate anyway. Spillover effects derive from customers who delivered energy or demand savings because of the program, but did not participate in the program or receive a financial incentive or rebate. Loss factors account for the fact that utilities must generate or import a greater amount of energy or demand than is required at the customer or end-user level because some energy is lost in distribution.

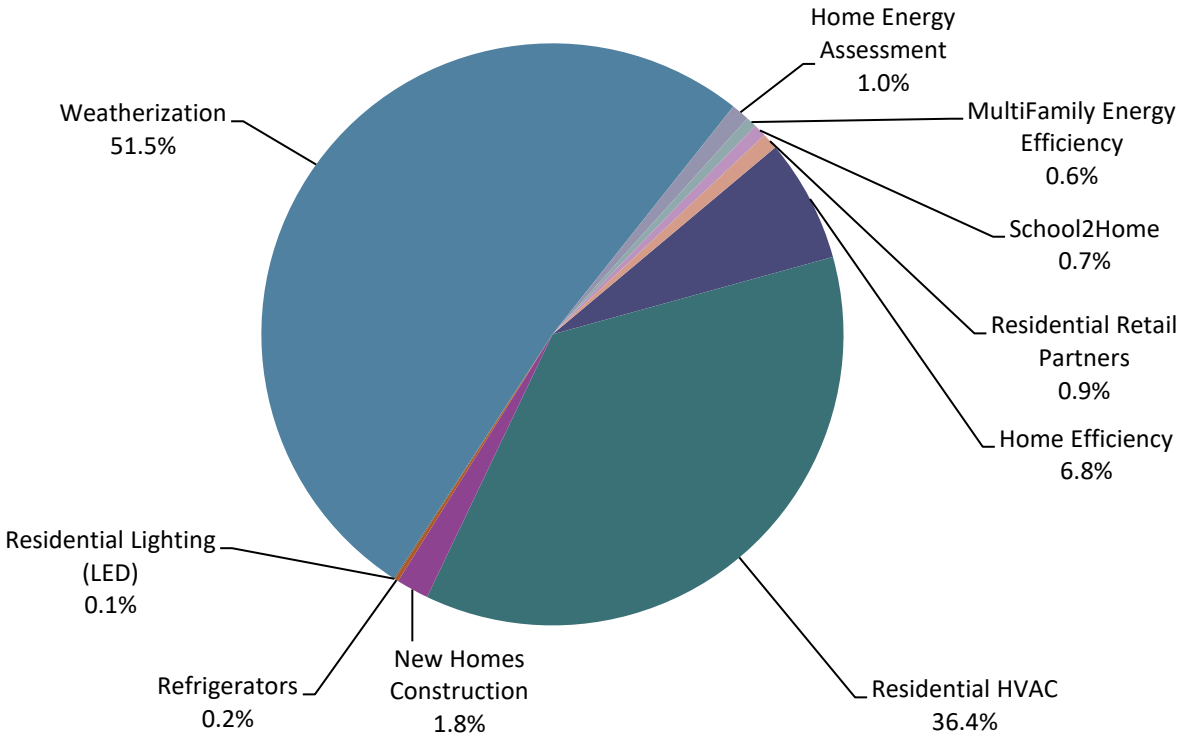

Figure 3-1: Summary of Residential Impacts – Coincident kW by Program

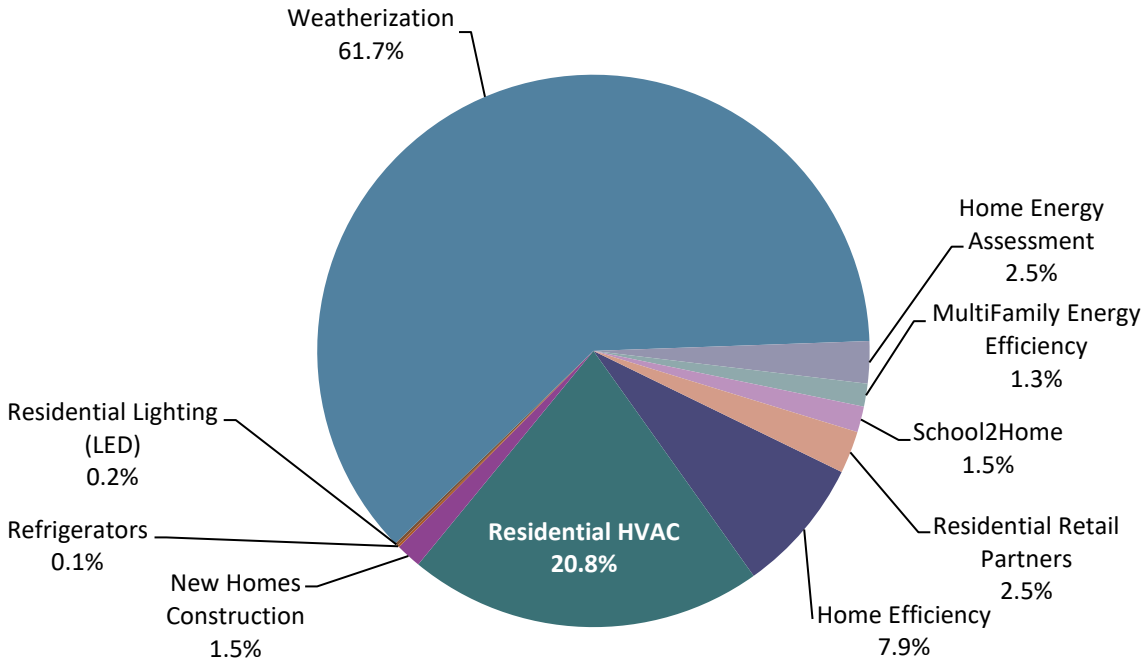

Figure 3-2: Summary of Residential Impacts – Non-Coincident kW by Program

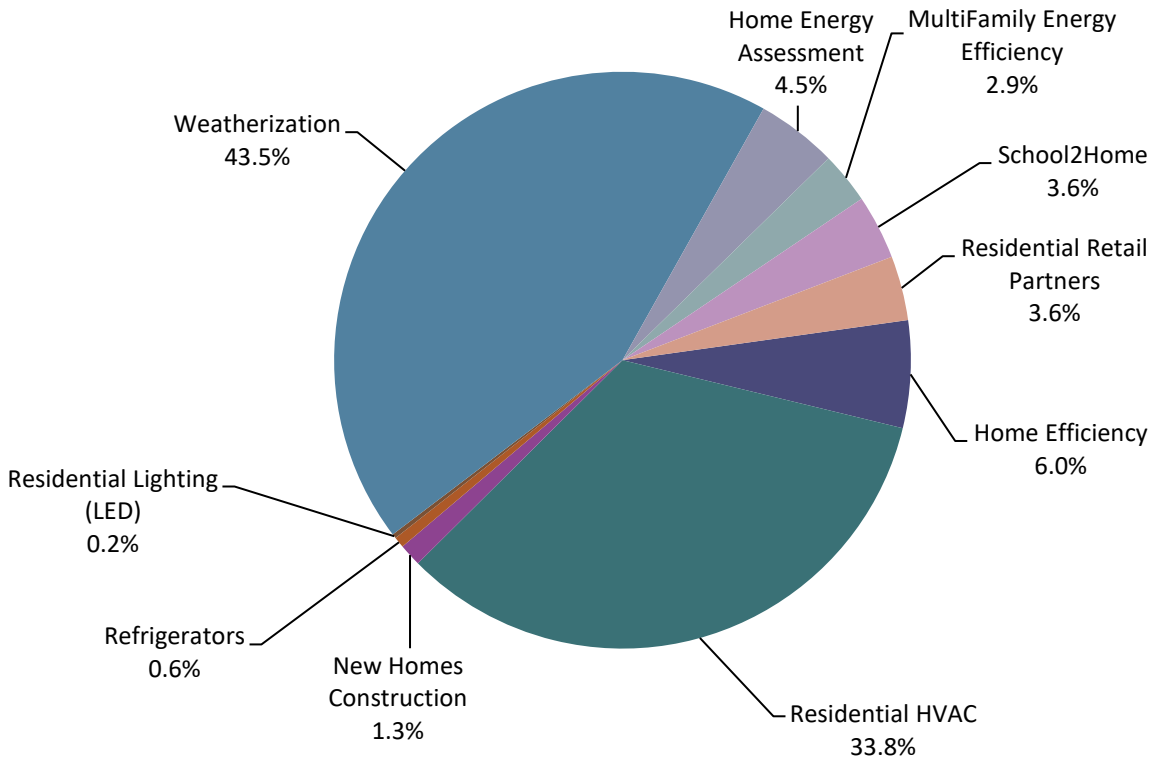

Figure 3-3: Summary of Residential Impacts – kWh by Program

3.2 HOME EFFICIENCY PROGRAM

3.2.1 Overview

CPS Energy's Home Efficiency program offers incentives for ceiling insulation, heat pump water heaters, and variable-speed pool pumps. Through the home efficiency program, CPS Energy and Franklin Energy implemented 1,389 total measures in FY 2017. The proportion of total energy savings derived from each measure type is presented in Figure 3-4.

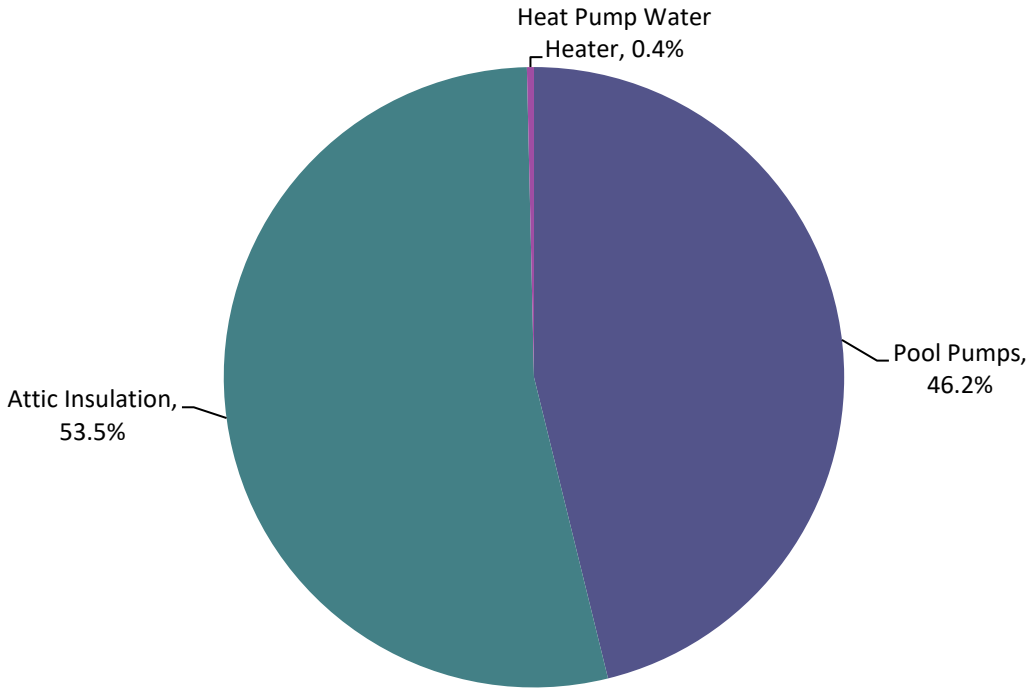

Figure 3-4: Home Efficiency – kWh by Measure

3.2.2 Savings Calculation Method

3.2.2.1 Ceiling Insulation

CPS Energy incentivized 1,065 ceiling insulation installations in FY 2017, compared with 1,666 ceiling insulation installations in FY 2016. Energy savings for this measure are determined using calibrated simulation models developed using NREL's BEopt 2.6 software running EnergyPlus 8.4 as the underlying simulation engine, presented in the *CPS Energy Guidebook* measure 6.2 Ceiling Insulation. Coincident, non-coincident, and 4CP peak demand savings were determined using the differences in energy use in specific hours of the simulations of the pre-retrofit and post-retrofit models.

Savings are determined per square foot of ceiling insulation installed. This measure applies to homes with electric air conditioning systems. In the *CPS Energy Guidebook*, cooling and heating savings factors are provided for every square foot of R-30 ceiling insulation installed in attics. Scale-down and scale-up

factors are used to when the average post-retrofit insulation depth provides less or more than R-30 insulation. Scale-down factors are provided for the case when average post-retrofit insulation depth is not sufficient to achieve R-30; scale-up factors are provided for the case when a contractor chooses to insulate to a level greater than R-30.

3.2.2.2 Heat Pump Water Heaters

The CPS Energy Home Efficiency program incentivized the installation of six heat pump water heaters (HPWH) in FY 2017, compared with ten from FY 2016. Heat pump water heaters work by using a small direct-exchange refrigeration system to remove heat from the ambient air and transfer that heat to the water in the storage tank. These units can provide Efficiency Factors (EF) in the 2.2 range, making them more than twice as efficient as conventional electric resistance water heaters.

Energy savings for this measure are calculated using Texas TRM v. 3.1. Coincident, non-coincident, and 4CP peak demand savings were calculated using a domestic hot water (DHW) load profile developed from the Building America Analysis Spreadsheet for existing homes.

Table 3-1: Home Efficiency Residential HPWH Deemed Annual Energy Savings (kWh)

Water Heater Location	Heating Type	HPWH Tank Size Range, Gallons			
		40	50	60	80
Conditioned Space	Gas	1,449	1,657	223	285
	Heat Pump	1,213	1,417	223	285
	Elec. Resistance	906	1,105	223	285
Unconditioned Space	N/A	1,273	1,481	219	280

The installations were assumed to be in unconditioned spaces. From Table 3-1, the average annual savings for the units installed is 1,281 kWh. This is a 6% reduction in savings per unit, compared to 1,361 in FY 2016, which is largely attributable to an increase in the baseline federal efficiency standard for water heaters greater than 55 gallons in size and the increased units in FY 2016.

The EUL for heat pump water heaters is 13 years, based on Texas TRM v. 3.1.

3.2.2.3 Variable-Speed Pool Pumps

Through the Home Efficiency program, CPS Energy provided incentives for the installation of 318 variable-speed pool pumps in FY 2017, compared to the 402 pool pumps installed in FY 2016. The energy and demand savings are determined using the deemed energy and demand savings tables in *CPS Energy Guidebook* measure 8.2 Variable Speed Drive Pool Pump. Coincident, non-coincident, and 4CP peak demand factors were calculated using a steady state pool pump load shape adapted for variable speed pool pumps developed from the Building America Analysis spreadsheet for existing homes.

The deemed energy and demand savings tables in the *CPS Energy Guidebook* includes savings for seven pool pump horsepower sizes, ranging from 0.5 to 3.0 horsepower. For pool pumps with a horsepower not included within the deemed energy and demand savings tables, the savings were applied for the closest appropriate horsepower.

3.2.3 Results and Recommendations

The total energy and demand savings for the Home Efficiency Program are as follows:

Table 3-2: Home Efficiency Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Pool Pumps	992,113	178.3	673.1	79.4
Attic Insulation	1,149,140	773.0	1,378.1	715.5
Heat Pump Water Heater	7,865	0.9	2.0	0.8
Total	**2,149,118**	**952.2**	**2,053.2**	**795.7**

3.3 RESIDENTIAL HVAC PROGRAM

3.3.1 Overview

CPS Energy's Residential Heating, Ventilation, and Air Conditioning (HVAC) Programs offer incentives to promote the installation of energy efficient HVAC equipment. The program covers the installation of central air conditioners (ACs), central heat pumps (HPs), window air conditioners (WACs), and ground source heat pumps (GSHPs). CPS Energy implemented the program in house for the first part of 2017, and transitioned the program to Franklin Energy for the latter part of 2017. In addition to the HVAC program, Franklin Energy also implemented the AC Duct Tune-up Program for residential consumers to incentivize AC diagnostic, cleaning, and refrigerant charge correction to improve efficiency and performance of existing systems.

CPS Energy's HVAC program included 6,901 projects in FY 2017, including 1,856 ACs, 1,326 HPs, 3,719 WACs, and 0 GSHPs. The Franklin Energy HVAC program included 3,240 projects in FY 2017, including 2,013 ACs, 1,103 HPs, 124 WACs, and 0 GSHPs. Combined, a total of 10,141 HVAC projects were completed in 2017, which is a 7% participation increase over the 9,437 projects completed in FY 2016.

The Franklin Energy AC Duct Tune-up program included 19 residential participants. No comparison can be made to participation in previous years because FY 2017 represents the inception of this program.

The figures below present a comparison of participation from FY 2014 to FY 2017 and a percentage breakdown of kWh energy savings by system. Note that for FY 2017, the participation reflected in the figure is a combination of the projects completed in the programs implemented by CPS Energy and Franklin Energy.

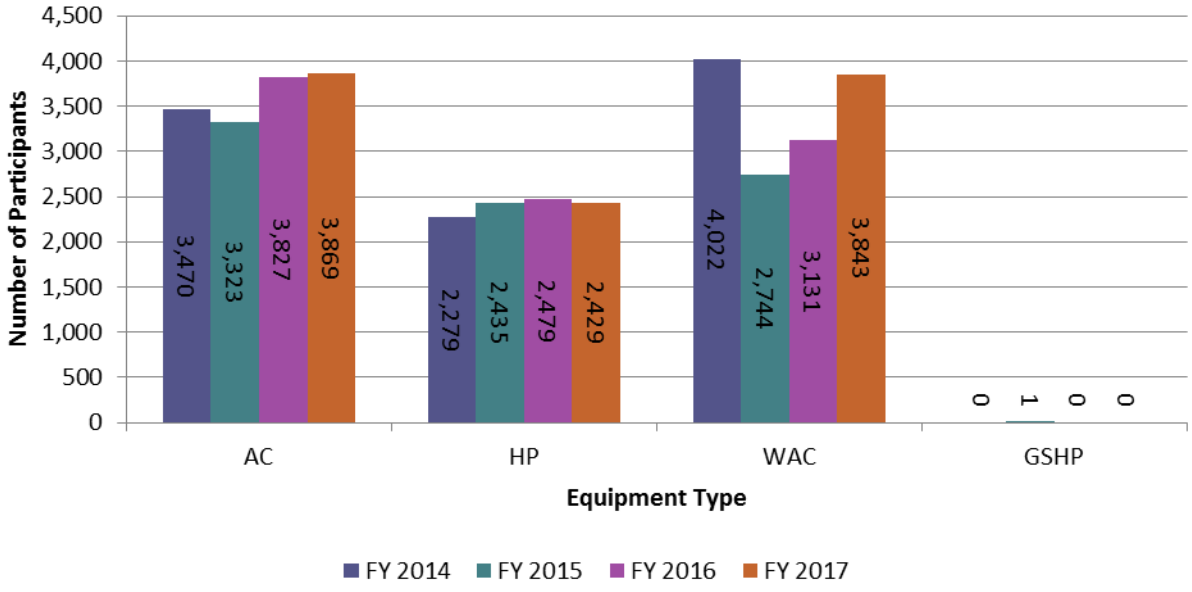

Figure 3-5: CPS Energy & Franklin Energy Residential HVAC – FY 2014, 2015, 2016, and 2017 Participation Comparison

3.3.2 Savings Calculation Method

HVAC

Energy and demand savings for ACs and HPs were estimated using deemed savings tables developed by Frontier Associates for the Texas Technical Reference Manual (TRM) version 3.1 and the *CPS Energy Guidebook*. Savings were estimated using air conditioner and heat pump performance curves developed by the National Renewable Energy Laboratory[6] for typical units in each of the following SEER ranges:

1. Baseline units
2. 14.5 – 14.9
3. 15.0 – 15.9
4. 16.0 – 16.9
5. 17.0 – 17.9
6. 18.0 – 20.9
7. 21.0 and above

These performance curves provide the capacity and efficiency of the heat pump operating in cooling mode across a wide range of outside air temperatures. Unit loading was estimated as a function of outside air temperature, and hours of cooling mode operation under different loadings were estimated using bin weather data for each weather zone. In heating mode, predicted HVAC operation was limited to meeting 77 percent of load, using a factor applied in Manual J to correlate design load hours to equivalent full load hours under actual operating conditions, taking into account that heating systems are not always operated even when outdoor conditions indicate they should.

Summer demand savings are estimated according to expected unit performance under design conditions. It is assumed that typical HVAC systems are sized to 115 percent of their design cooling load (oversized by 15 percent). Heating mode capacity was related to rated cooling capacity using the rated capacity in cooling and heating mode of the residential market heat pump products of four major manufacturers according to data exported from AHRI. Data was exported from the AHRI directory and the average ratio for each equipment size (1 ton, 1.5 ton, 2 ton, etc.) of heating capacity to cooling capacity was multiplied by the rated (cooling side) capacity to estimate the heat pump capacity. Heat pump system output was then compared to its loading under design conditions.

The model uses a set of normalized performance curves to scale the rated performance values as a function of outdoor dry-bulb temperature ranging from 65 to 115 degrees Fahrenheit. The total capacity and Energy Input Ratio (EIR = 1/COP) curves are a function of entering wet-bulb temperature (EWB) and outdoor dry-bulb temperature (ODB) with quadratic curve fittings.

Similarly, energy and demand savings for window air conditioners were estimated using algorithms developed by Frontier for TRM 3.1 and the CPS Energy Guidebook. In general, savings are estimated by

[6] D. Cutler et al., Improved Modeling of Residential Air Conditioners and Heat Pumps for Energy Calculations. National Renewable Energy Laboratory. NREL/TP-5500-56354. January 2013. Tables 12 and 13. http://www.nrel.gov/docs/fy13osti/56354.pdf.

multiplying the installed capacity by the change in system efficiency. The typical format of the savings formula for this measure is as follows:

$$kW_{Savings} = \frac{Capacity}{1{,}000} \times \left(\frac{1}{Efficiency_{Baseline}} - \frac{1}{Efficiency_{Installed}}\right) \times Demand\ Factor$$

$$kWh_{Savings} = \frac{Capacity}{1{,}000} \times \left(\frac{1}{Efficiency_{Baseline}} - \frac{1}{Efficiency_{Installed}}\right) \times Hours$$

Deemed savings and algorithm assumptions specified in the *CPS Energy Guidebook* replaced any weather specific assumptions with San Antonio climate data. Refer to the *CPS Energy Guidebook* for a detailed overview of the savings methodologies for each measure. There is also specific direction on how to claim savings when using the early retirement baseline for any of the above measures.

There were no reported GSHP projects, but any future projects will be evaluated as outlined in the Texas TRM and *CPS Energy Guidebook* specified for the applicable fiscal year.

AC Duct Tune-up

Savings for all sampled projects for the AC Duct Tune-up measure were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. General savings algorithms are specified below.

$$Energy\ (Cooling)\ [kWh_{Savings,C}] = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times \frac{EFLH_C}{1{,}000}$$

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, non-coincident peak (NCP) demand savings were determined by identifying the maximum demand reduction during the entire year. Coincident peak (CP) demand savings were calculated according to the procedure outlined in Section 2.2 of the *CPS Energy Guidebook*. ERCOT 4CP Transmission cost savings were calculated using the procedure outlined in Section 2.4.2 of the *CPS Energy Guidebook*.

3.3.3 Equipment Verification

To verify the accuracy of the reported equipment specifications, Frontier reviewed reported system capacities and efficiencies against those validated by the Air Conditioning, Heating, and Refrigeration Institute (AHRI)[7] for each AC and HP project included in the random sample. In future program years, Frontier expects Franklin Energy to provide WAC model numbers that can be compared to manufacturer specification sheets and/or equipment information maintained by ENERGY STAR.[8] Very few discrepancies were found among projects implemented by either CPS Energy or Franklin Energy. For CPS Energy, 34 of 35 AC projects and 17 of 19 HP projects matched values reported by AHRI. For Franklin Energy, 39 of 40 AC projects and 22 of 24 HP projects matched values reported by AHRI. The

[7] AHRI Certification Directory: https://www.ahridirectory.org/ahridirectory/pages/home.aspx.
[8] ENERGY STAR Certified Room Air Conditioners: http://www.energystar.gov/productfinder/product/certified-room-air-conditioners/.

discrepancies identified were minor enough that there was no effect on the savings calculation for those units. Based on these results, the evaluation team opted to make no adjustments to reported savings.

3.3.4 Results and Recommendations

The weighted average NCP kW demand realization rates for the residential HVAC projects implemented by CPS Energy were 124.2% for ACs, 122.8% for HPs, and 32.5% for WACs. The weighted average kWh energy realization rates were 120.6% for ACs, 83.6% for HPs, and 19.6% for WACs. The overall weighted average realization rates were 104.7% for NCP kW demand savings and 87.6% for kWh energy savings. Savings for WACs were lower than for the other programs based on the implementation of an outdated baseline.

The weighted average NCP kW demand realization rates for residential HVAC projects implemented by Franklin Energy were 98.7% for ACs, 98.5% for HPs, and 428.3% for WACs. The weighted average kWh energy realization rates were 99.8% for ACs, 106.1% for HPs, and 194.1% for WACs. The overall weighted average realization rates were 99.0% for NCP kW demand savings and 102.1% for kWh energy savings. Savings for WACs were higher than for the other measures based on Franklin Energy's decision to calculate deemed savings for two tiers based using very conservative assumptions rather than calculating savings for each specific installation.

An estimated useful life (EUL) of 18 years for ACs, 15 years for HPs, and 8 years for WACs was applied to the verified savings for all projects implemented by CPS Energy. For projects implemented by Franklin Energy, the EUL for ACs was reduced to 17.84 to account for a subset HP installations that were mistakenly identified as ACs installations. There was no adjustment made to the EUL for HP or WAC installations for Franklin Energy projects.

Total energy and demand savings for the installation of ACs, HPs, and WACs for CPS Energy implemented program are included in the following table:

Table 3-3: CPS Energy Residential HVAC Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Non-Coincident kW Savings	Annual Coincident Peak kW Savings	TCOS 4CP kW Savings
Central Air Conditioners	3,336,871	1,536.64	1,478.04	1,266.26
Central Heat Pumps	2,363,676	929.31	843.18	750.31
Window Air Conditioners	229,903	170.17	156.05	145.67
Total	**5,930,450**	**2,636.12**	**2,477.27**	**2,162.24**

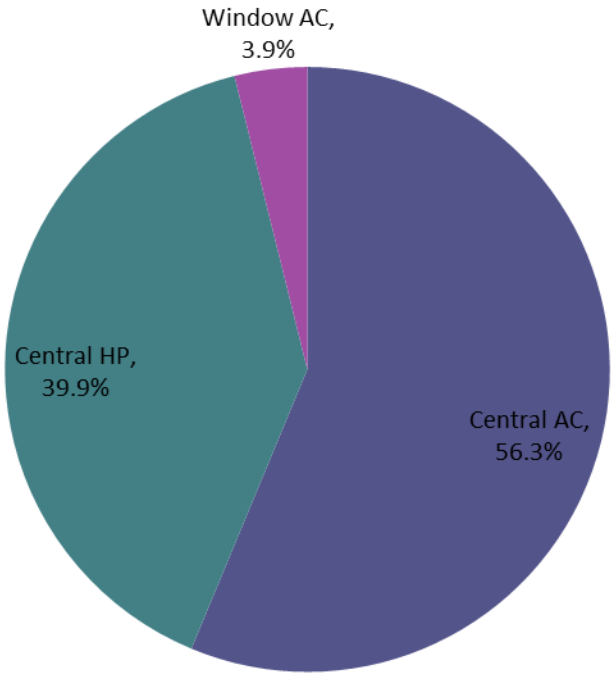

Figure 3-6: CPS Energy Residential HVAC – Percent of kWh Savings by System Type

Total energy and demand savings for the installation of ACs, HPs, and WACs and for the completion of AC duct tune-up projects for Franklin Energy implemented programs are included in the following table:

Table 3-4: Franklin Energy Residential HVAC Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Non-Coincident kW Savings	Annual Coincident Peak kW Savings	TCOS 4CP kW Savings
Central Air Conditioners	3,812,273	1,778.11	1,714.35	1,449.09
Central Heat Pumps	2,044,566	845.89	766.45	679.72
Window Air Conditioners	15,145	11.21	10.28	9.60
AC Duct Tune-up	4,545	1.18	1.09	1.01
Total	**5,876,529**	**2,636.39**	**2,492.17**	**2,139.42**

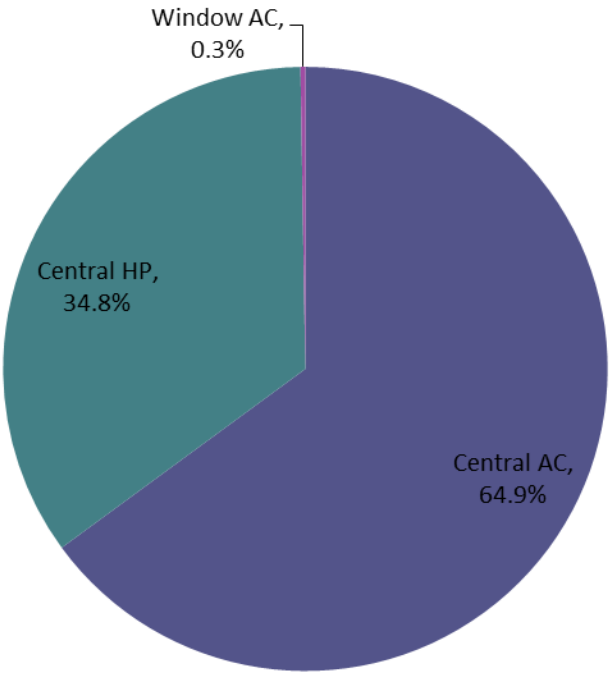

Figure 3-7: Franklin Energy Residential HVAC – Percent of kWh Savings by System Type

Frontier's recommendations for future implementation of the Residential HVAC Program are as follows. Most of these recommendations are primarily directed towards the Franklin Energy implemented program, which is replacing the program implemented by CPS Energy for FY 2018.

- For projects implemented by CPS Energy, additional savings could be available to units that are still functional by applying the early retirement baseline. In order to apply this baseline, one must collect the system type, manufacturer, model number, and age of the existing equipment and follow the early retirement weighting strategy outlined in the CPS Energy Guidebook.
- Require AHRI certificate for every installation. For a small subset of sampled projects, Franklin Energy noted that no AHRI certificate was available. However, in most cases, the AHRI certificate was made available after a follow-up request from the evaluation team. If no AHRI certificate can be provided, that project should not be eligible to receive an incentive.
- Model numbers should be provided to the evaluation team for all system components, including the condenser, coils, and furnace, so that they can be verified against the AHRI certificate.
- Frontier understands that in order to simplify implementation, Franklin Energy has opted to utilize a savings estimation strategy to create deemed savings values for various tiers of products. There is a counteractive relationship between savings precision and ease of implementation. However, savings claims would benefit from the creation of additional savings tiers for ACs, HPs, and WACs.

  - For AC & HP cooling savings, Franklin Energy has indicated that they may be moving to requiring a minimum 16 SEER full-load efficiency. The savings specified for 16 and 17 SEER systems are very similar, but the savings increase substantially at 18 SEER and again at 21 SEER. At a minimum, Frontier recommends the following tiers for the AC and HP measures: 16-17.9 SEER, 18-20.9 SEER, and 21.0+ SEER.
  - For HP heating savings, Frontier understands Franklin Energy currently has a tier for units with a heating efficiency of 8.2 HSPF. The CPS Energy Guidebook does not specify heating savings for anything below 8.5 HSPF. Frontier recommends that Franklin Energy eliminate the 8.2 HSPF category from their program.
  - For WACs, Frontier recommends that Franklin Energy adjust the existing tier specified for less than or equal to 8,000 btu/hr capacity category to less than 8,000 btu/hr, and, similarly, change the greater than 8,000 btu/hr capacity category to greater than or equal to 8,000 btu/hr. This is consistent with the implementation of the current federal standard for room air conditions. The endpoint capacity is typically included with the larger size category. This change will help to improve the baseline used for systems where the installed capacity matches the endpoint of one of the baseline capacity ranges.
  - Additionally for WACs, Frontier recommends that Franklin Energy add a new tier for capacities greater than or equal to 20,000 btu/hr. For units of this size, the baseline efficiency drops from 10.7 EER to 9.4 EER. It drops again to 9.0 EER for units greater than or equal to 25,000 btu/hr, but it could be reasonable to combine these size categories in the name of ease of implementation.

- Ensure that program minimum efficiency requirements are enforced for all measures, even when deemed savings are applied to different savings categories. For ACs and HPs, those minimum efficiency values correspond to 14.5 SEER, 12.0 EER, 8.5 HSPF for new construction and replace-on-burnout projects. For WACs, the installed efficiency should exceed the baseline efficiency. For at least one WAC installation among the project sample, savings were claimed for a unit where the installed efficiency was equal to the baseline efficiency. For other WAC installations, savings were awarded to units where no installed efficiency value was collected. In these cases, after confirming with Franklin Energy that no value was collected, Frontier assumed that the installed efficiency was equal to the baseline and awarded no savings for that installation.

Frontier's recommendations for future implementation of Franklin Energy's AC Tune-up Program are as follows:

- Additional data should be collected, including system type and cooling capacity for each tune-up. Savings can vary depending on whether equipment is an AC or HP as well as by the size of the unit. While the CPS Energy Guidebook provides default values for capacity, these values are intended to be used only when the tonnage is not able to be determined on site. Using

these assumptions for all tune-up projects could negatively affect the overall precision of evaluated savings.

- Method of calculating efficiency loss should be communicated at the beginning of the program year. This can be done with an M&V plan and efficiency loss factor derivation being provided to the evaluation team.

3.4 NEW HOMES CONSTRUCTION PROGRAM

3.4.1 Overview

CPS Energy's FY 2017 new residential construction program provided incentives for 390 new homes completed in FY 2017, down from the 1,393 homes in the FY 2016 program and the 2,139 homes participating in the program in FY 2015. The transition to IECC 2015 as the residential energy code establishing the baseline for CPS Energy's new residential construction program that occurred in July 2015 continued to have a significant impact on the program in FY2017, as many builders who stopped participating in 2016 continued to sit out the program in FY 2017. Eight builders participated in the program, down from 17 in FY 2016. Ratings were provided by five raters.

CPS Energy eliminated its two-tiered incentive structure in FY 2017, and instead paid incentives based on construction of homes that are expected to consume at least 15 percent less total source energy (electricity and gas) than a home built to the requirements of IECC 2015. CPS Energy increased the incentive rate from $800 to $1300 per qualifying home during the program year.

Table 3-5: New Residential Construction –FY 2017 Incentive Levels

Incentive Amount ($)	Requirement	Effective Date	Participating Homes
$800	15% better than IECC 2015	Jan – May	121
$1,300	15% better than IECC 2015	May - Dec	269

Participants could also qualify by obtaining certification through the Build San Antonio Green (BSAG) program. The Build San Antonio Green single family new construction program incorporates other elements in addition to energy consumption to achieve its certification including water, site, and health requirements. BSAG also require a HERS rating and meeting of all the requirements of the Energy Star New Homes program.

3.4.2 Participation Trends

Eighty-seven of the 390 homes participating in the FY2017 program were certified by BSAG. These homes were built by four builders, two of which were responsible for all but five (82) of the homes. Six of the seven participating builders submitted homes directly to CPS Energy. Two builders were responsible for 276 of the homes.

Table 3-6: New Residential Construction – Program Participation by Path

Participation Path	Homes	Builders	Total
CPS Direct	303	6	1,348
BSAG Certification	87	4	45
Total	**390**	**7**	**1,393**

3.4.3 Savings Calculation Methods

Homes are accepted to the program based on ratings developed using the Energy Systems Lab's (ESL) International Code Compliance Calculator (IC3) and Architectural Energy Corporation's REM/Rate, the software used to establish Energy Star program compliance. Both tools provide site and source energy savings estimates based on a comparison of the predicted energy use in the as-built home to the energy use the models predict for a reference model, which incorporates the features of a home built to the reference code (IECC 2015) and equipped to relevant standards (e.g. federal equipment efficiency standards for HVAC units, water heaters, etc.). Source energy savings estimates are the basic requirement for establishing whether program guidelines have been met and the incentive tier for a given project. However, neither tool provides the coincident peak (CP), ERCOT 4 CP (4CP) or non-coincident peak (NCP) demand savings needed for benefit-cost analysis of the residential new construction program.

Frontier employed BEopt residential building energy use simulation software to develop models representative of the general suites of measures being incorporated into participating homes by the different builders to verify the energy savings estimates from the rating tools and to estimate CP, 4CP and NCP demand savings. The base Frontier model is a simple single-story square home with unfinished attic, built on a slab. The reference model is populated in accordance with the requirements for creating a standard reference model in Section R405 of the IECC 2015.

Builders are using a wide array of measures to meet program requirements: some have gone to 2x6 walls with R-19 insulation; some are also adding continuous rigid insulation around the exterior of the homes. A majority of homes have 16 SEER air conditioners (or 16 SEER/8.5 and higher HSPF heat pumps), and some have tankless water heaters. Many are bringing the attics inside the envelope, insulating at the roof deck and completely sealing the attic; almost all are installing radiant barriers.

Perhaps the most important feature in determining by how much participating homes beat code is in reducing air infiltration. Code requires homes not allow more than 5 air changes per hour during blower door testing (pressurized to 50 pascals): reported air infiltration rates from post-construction blower door tests were between 2 and 5 ACH_{50}.

After reviewing the data from the IC3 reports and supplemental information requested (as listed in the *CPS Energy Guidebook* section for this program), Frontier developed simulation models reflecting the basic packages implemented by each of the builders, and ran simulations on variations of these models

reflecting important differences such as the size (conditioned floor area) and achieved air infiltration rate.

3.4.3.1 Energy Savings (kWh)

While some variance is observed between homes, overall the energy savings from homes participating directly and submitting homes modeled in IC3 are producing savings in line with those estimated by the rating software.

Table 3-7: New Residential Construction - Site Electric Energy Savings Estimates

Participation Path	Est. Percent Improvement over Code	IC3 Ave. Site Energy Savings (kWh/100 ft2)	BEopt Site Energy Savings (kWh/100 ft2)	Percent Difference
Direct	16-32	46	46	0%

Homes entering the program through BSAG certification are estimated to achieve even higher normalized savings: Frontier's modeling indicates these homes are delivering about 85 kWh/100 ft^2 annually.

In aggregate, Frontier estimates that participating homes completed during FY 2017 will deliver approximately 418,000 kWh of annual energy savings.

3.4.3.2 Coincident Peak (CP) Demand Savings (kW)

Frontier used delta load shapes from model runs to extract energy use in likely coincident peak (CP) hours and estimate CP demand savings for participating homes. In all, Frontier estimates that the FY 2017 participating new homes will provide 235 kW of CP demand savings.

3.4.3.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Frontier extracted the maximum hourly value from the delta load shapes from its model runs to estimate the NCP demand savings for participating homes. In all, Frontier estimates that the FY 2017 participating new homes will provide 360 kW of NCP demand savings.

3.4.3.4 ERCOT 4CP Demand Savings (kW)

Frontier used the delta load shapes from its model runs to extract energy use in likely ERCOT 4CP hours. In all, Frontier estimates that the FY 2017 participating new homes will provide 283 kW of demand savings during the ERCOT 4CP.

3.4.4 Impact Analysis Results

The estimated energy savings and coincident peak, non-coincident peak, and ERCOT 4CP demand savings for the FY 2017 residential new construction program are presented in Table 3-8.

Table 3-8: New Residential Construction Gross Energy and Demand Savings

Participant Type	Participant Count	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Direct	303	304,903	245	157	186
Build San Antonio Green	87	113,053	115	78	97
Total	**390**	**417,956**	**360**	**235**	**283**

3.4.5 Recommendations

Frontier recommends that CPS Energy undertake a builder-by-builder performance review to evaluate the approaches being undertaken by each builder to meet the program requirements. Incentive levels may also need to be further revised to entice builders back into the program. CPS Energy has indicated that incentive rates were increased to $1,300 as of May 2016, and early returns are positive for FY 2018.

3.5 REFRIGERATOR PROGRAM

3.5.1 Overview

CPS Energy implements a refrigerator efficiency program that incorporates two elements: (1) a rebate program to encourage the purchase of ENERGY STAR new refrigerators and; (2) a recycling program to remove older, less-efficient units. Customers receive a $65 incentive for recycling a working refrigerator, and $35 for the purchase of an ENERGY STAR model.

Unlike other programs to promote the purchase of energy-efficient products, energy savings from programs to incentivize the purchase of more-efficient refrigerators are not immediately realized upon the installation of the more-efficient unit. This is because older units often are kept operating as secondary units. According to the most recent US EIA Residential Energy Consumption Survey (RECS),[9] 21% of Texas households have two or more refrigerators. These secondary units are often located in unconditioned spaces, which results in increased summer peak demand.

In FY 2017, 278 units were recycled, compared with 517 from FY 2016. In FY 2017, 142 customers received an incentive for the purchase of an ENERGY STAR model. This total is down from 330 in FY 2016, most likely due to the program being retired as of June 2016.

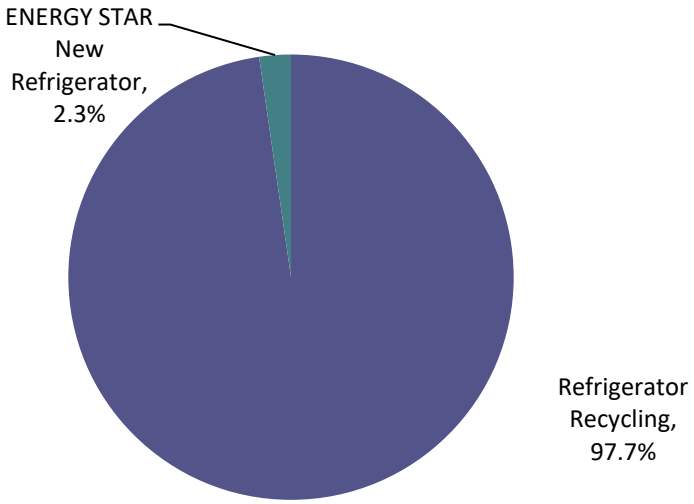

Figure 3-8: Refrigerator Program – kWh by Measure

3.5.2 Savings Calculation Method

For the refrigerator replacement measure, energy savings are estimated using a methodology from Texas TRM v. 3.1. This methodology was updated from earlier versions of the TRM, as the ENERGY STAR standard was updated in 2014. A replace-on-burnout scenario is assumed.

[9] US Energy Information Administration. "Residential Energy Consumption Survey." Accessed April 27, 2016. http://www.eia.gov/consumption/residential/index.cfm

Market shares of product types and adjusted volumes came from the 2011 Technical Support Document.[10]

Table 3-9: Refrigerator Program ENERGY STAR Deemed Energy Savings

	Top-Freezer	Bottom Freezer	Side-by-Side
Market Share	53.9%	13.6%	32.4%
Adjusted Volume	21.44	23.12	31.45
Baseline kWh	406.7	521.6	701.4
Energy Star kWh	366.0	469.5	631.2
kWh Savings	40.7	52.2	70.1
Average kWh	51.7		
Average kW	0.0075		

Texas TRM v. 3.1 contains a method for calculating energy and peak demand savings associated with refrigerator recycling and refrigerator replacement.

Energy savings are calculated as follows:

$$kWh_{savings} = kWh_{existing} \times ISAF \times PUF$$

Where:

$kWh_{existing}$ = Average annual energy consumption[11] = 1,308 kWh

$ISAF$ = In Situ Adjustment Factor[12] = 0.942

PUF = Part Use Factor[13] = 0.915

$kWh_{savings}$ = 1,227

Coincident, non-coincident, and 4CP peak demand savings were calculated using a refrigerator load profile developed from the Building America Analysis Spreadsheet for existing homes.[14]

[10] https://www1.eere.energy.gov/buildings/appliance_standards/pdfs/refrig_finalrule_tsd.pdf

[11] The Cadmus Group, Inc. "Residential Retrofit High Impact Measure Evaluation Report". Prepared for California Public Utilities Commission Energy Division. February 8, 2010. Average of DOE-Based Full-Year Unit Energy Consumption (weighted by representative utility survey participation).

[12] Ibid. Factor to account for variation between site conditions and controlled DOE testing conditions (90 °F test chamber, empty refrigerator and freezer cabinets, and no door openings). Appliances in warmer climate zones use more energy than those in cooler climate zones; utilized SCE data (highest percentage of warm climate projects) to best approximate Texas climate, p. 139-140.

[13] Ibid. Factor to account for the number of refrigerators that were running, running part time, or not running at the time of recycling, p. 142-143 (weighted by representative utility survey participation, p. 117).

3.5.1 Results and Recommendations

The EUL for ENERGY STAR refrigerators is 16 years, based on Texas TRM v. 3.1. For the recycling measure, the EUL is 8 years, based on the assumed remaining service life of the recycled unit.

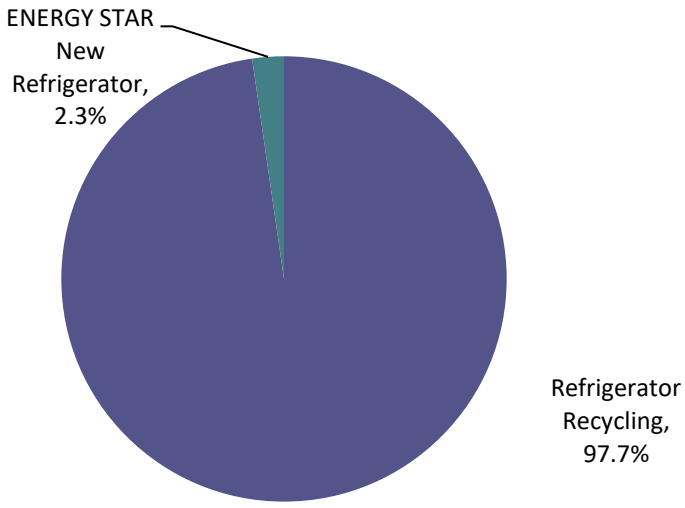

Figure 3-9: Refrigerator Program – kWh by Measure

Gross energy and demand savings for the refrigerator program are shown below.

Table 3-10: Refrigerator Program Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Refrigerator Recycling	313,418	40.6	47.4	41.3
ENERGY STAR Replacements	7,341	1.0	1.1	1.0
Total	**320,760**	**41.6**	**48.5**	**42.3**

[14] Building America Analysis Spreadsheet for existing homes, accessed on March 1, 2017 from http://energy.gov/eere/buildings/downloads/building-america-analysis-existing-homes.

3.6 WEATHERIZATION PROGRAM

3.6.1 Overview

CPS Energy's residential weatherization program provides comprehensive retrofits for income-eligible customers. In FY 2017, the program provided a range of services to 3,900 customers, compared with 4,051 customers in FY 2016. A total of 122,533 individual measures were installed in FY 2017. These measures included repair, health & safety, and energy-saving measures. The energy-saving measures may be categorized as follows:

- CFL light bulbs
- LED light bulbs
- Wall insulation
- Ceiling insulation
- Floor insulation
- Solar screens
- Water heater pipe insulation
- Water heater insulation
- Low-flow showerheads
- Air infiltration reduction
- Duct system improvement
- Faucet Aerators

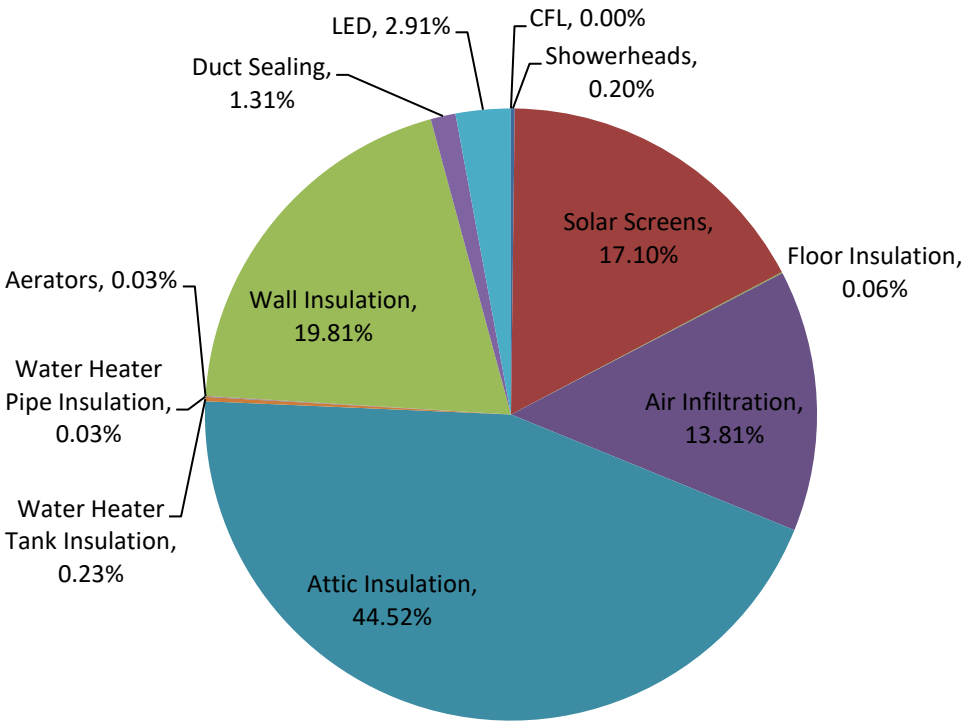

Figure 3-10: Weatherization – Coincident kW by Measure

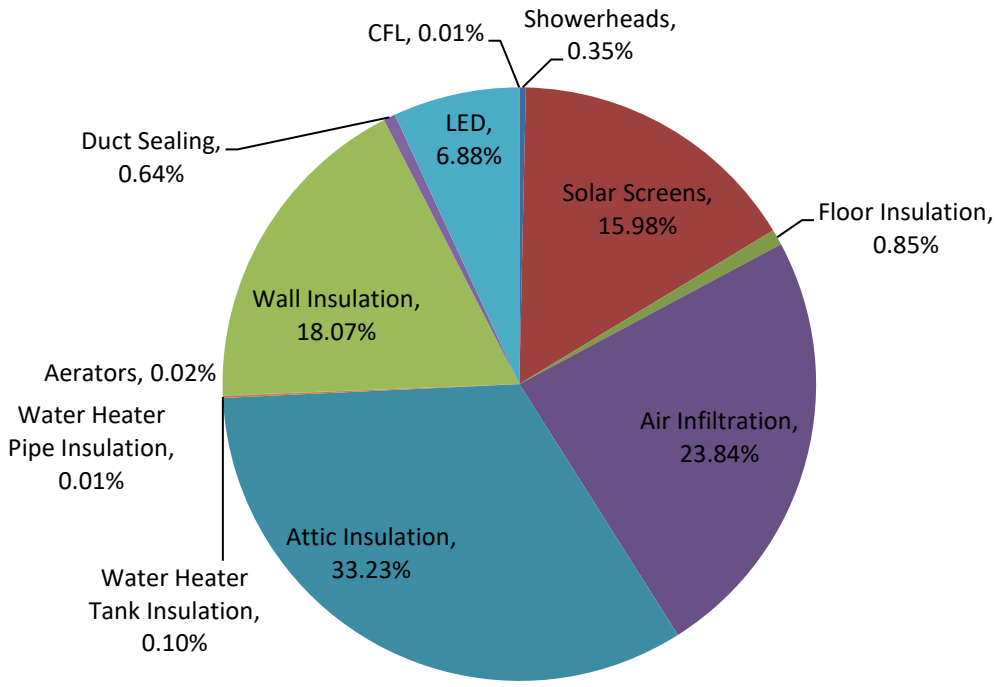

Figure 3-11: Weatherization – Non-Coincident kW by Measure

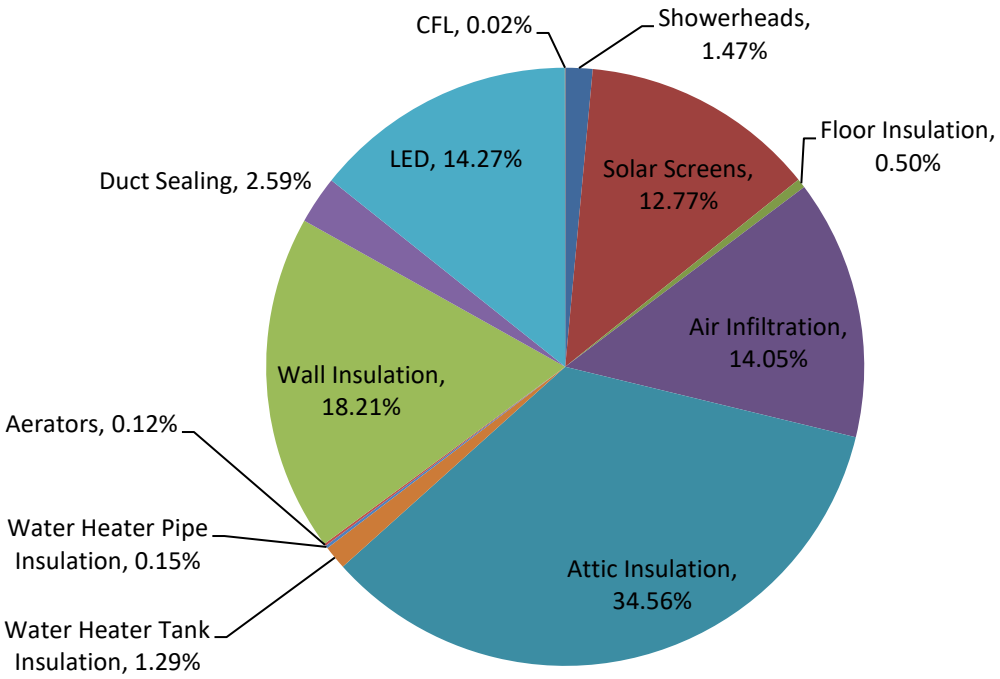

Figure 3-12: Weatherization – kWh by Measure

3.6.2 Savings Calculation Method

For each of the measures, Frontier determined energy savings using methodology from the *CPS Energy Guidebook*.

3.6.2.1 Compact Fluorescent Lamps (CFLs)

As part of the program, CPS Energy installed 334 thirteen-watt CFLs in FY 2017. Franklin Energy did not install CFLs in their implementation of the weatherization program. Energy savings estimates are based on the assumption that each CFL replaces an incandescent lamp of roughly equivalent lumen output. The energy and demand savings are determined using the CPS Energy Guidebook measure 4.1 Standard Compact Fluorescent Lamps. Coincident, non-coincident, and 4CP peak demand factors were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes.

There is a two-step savings calculation for this measure, due to the baseline change that is scheduled to occur in 2020. Interactive effects factors were applied to account for the impacts on cooling and heating loads for different heating and cooling types. Tiered savings are discounted by a rate of 3% to assume a 97% in-service rate.

3.6.2.2 LED Lamps

105,811 LED Omni-Directional Lamps, LED Flood Lights, and LED Candelabras were installed by CPS Energy and Franklin Energy in FY 2017. The energy and demand savings are determined using the *CPS Energy Guidebook* measure 4.3 ENERGY STAR® Omni-directional LED Lamps and measure 4.4 ENERGY STAR® Specialty and Directional LED Lamps. Coincident, non-coincident, and 4CP peak demand factors were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes.

EISA-affected bulbs had savings determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The *CPS Energy Guidebook* also incorporates an interactive effects factor to account for the impacts on cooling and heating loads for different heating and cooling types. Savings are discounted by a rate of 3% to assume a 97% installation rate.

3.6.2.3 Wall Insulation

CPS Energy and Franklin Energy installed wall insulation in 1,998 homes in FY 2017. Energy savings for this measure are determined using calibrated simulation models developed using NREL's BEopt 2.6 software running EnergyPlus 8.4 as the underlying simulation engine, presented in the *CPS Energy Guidebook* measure 6.3 Wall Insulation. Coincident, non-coincident, and 4CP peak demand savings were determined using building energy simulation models developed by subtracting the whole house energy use in each hour of the post-retrofit models from the energy use in the pre-retrofit models.

Energy and demand savings are based on the assumption that a previously-uninsulated wall cavity is insulated to R-13, typically by blowing in cellulose insulation. Savings are determined per square foot of wall insulation installed.

3.6.2.4 Ceiling Insulation

As part of the weatherization program, CPS Energy and Franklin Energy installed 3,267 ceiling insulation measures in FY 2017. Energy savings for this measure are determined using calibrated simulation models developed using NREL's BEopt 2.6 software running EnergyPlus 8.4 as the underlying simulation engine, presented in the *CPS Energy Guidebook* measure 6.2 Ceiling Insulation. Coincident, non-coincident, and 4CP peak demand savings were determined using the differences in energy use in specific hours of the simulations of the pre-retrofit and post-retrofit models.

Savings are determined per square foot of ceiling insulation installed. This measure applies to homes with electric air conditioning systems. Cooling and heating savings factors are provided for every square foot of R-30 ceiling insulation installed in attics. Scale-down and scale-up factors are used to when the average post-retrofit insulation depth provides less or more than R-30 insulation. Scale-down factors are provided for the case when average post-retrofit insulation depth is not sufficient to achieve R-30; scale-up factors are provided for the case when a contractor chooses to insulate to a level greater than R-30.

3.6.2.5 Floor Insulation

As part of the Weatherization program, CPS Energy and Franklin Energy installed floor insulation in 200 homes during FY 2017. Energy and demand savings for this measure are determined using the *CPS Energy Guidebook* measure 6.4 Floor Insulation deemed savings tables. Coincident, non-coincident, and 4CP peak demand savings were calculated using residential heating and cooling load profiles developed using US DOE's BEopt and EnergyPlus residential simulation modeling software.

The baseline is assumed to be a site-built house with pier and beam construction and no floor insulation against the floor of the conditioned area. For homes listed as having "mixed" heating fuels, Frontier averaged the gas heat and electric heat savings values.

3.6.2.6 Solar Screens

As part of the Weatherization program, CPS Energy and Franklin Energy installed solar screens on 3,674 homes during FY 2017. Energy and demand savings for this measure are determined using the *CPS Energy Guidebook* measure 6.5 Solar Screens deemed savings tables. Coincident, non-coincident, and 4CP peak demand savings were calculated using residential heating and cooling load profiles developed using US DOE's BEopt and EnergyPlus residential simulation modeling software.

The baseline is a single pane, clear glass, unshaded, east-, west-, or south-facing window with a solar heat gain coefficient of 0.75. For homes listed as having "mixed" heating fuels, Frontier averaged the gas heat and electric resistance heat savings values. Note that for this measure, the Guidebook applies a heating penalty to account for the reduction in solar heat gain during the heating season.

For this measure, installed quantity was provided in united inches (window width plus height, in inches). This is the typical pricing unit for contractors. *CPS Energy Guidebook* savings values are per square foot of treated window area. To convert united inches to square feet, Frontier assumed an average dimension of three feet by five feet. To reduce the potential error in the savings estimate resulting from this assumption, Frontier recommends that total square feet of solar screens installed per home be captured, in addition to united inches.

3.6.2.7 Water Heater Pipe Insulation

As part of the Weatherization program, CPS Energy and Franklin Energy installed water heater pipe insulation in 672 homes during FY 2017. A total of 3,783 linear feet of pipe insulation was installed, for an average of 5.6 feet per installation. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.3 Pipe Insulation. Coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

The savings are based on an assumed baseline of a typical electric water heater without insulation on the water heater pipes. Savings for water heater pipe insulation are based on a maximum allowable insulation length of 6 feet of piping per installation, as per the *CPS Energy Guidebook*. For any installation of water heater pipe insulation over six feet, the savings were capped at this maximum.

3.6.2.8 Water Heater Insulation

As part of the Weatherization program, CPS Energy and Franklin Energy installed water heater insulation on 686 water heaters during FY 2017. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.4 Water Heater Insulation. Coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

The baseline is assumed to be a typical electric water heater with no insulation. Savings are determined using an assumption of a 40 gallon water heater of standard height and diameter, providing a tank surface area of 21.81 as per the *CPS Energy Guidebook*. The R-value of the installed insulation is assumed to be 5 and the water heater is assumed to be in a conditioned space.

3.6.2.9 Low-Flow Showerheads

As part of the Weatherization program, CPS Energy and Franklin Energy installed 803 low-flow showerheads in homes with electric water heaters during FY 2017. The energy and demand savings are determined using the algorithms in the CPS Energy Guidebook measure 7.2 Showerheads. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead.

3.6.2.10 Air Infiltration Reduction

As part of the Weatherization program, CPS Energy and Franklin Energy installed air infiltration control measures in 3,352 homes in FY2017. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 6.1 Air Infiltration. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Deemed savings are presented as a function of the CFM_{50} reduction achieved, as demonstrated by blower door testing. For homes listed as having "mixed" heating fuels, Frontier averaged the gas heat and resistance heat savings values.

3.6.2.11 Duct System Improvement

As part of the Weatherization program, CPS Energy and Franklin Energy installed duct efficiency measures in 1,120 homes in FY2017. The *CPS Energy Guidebook* measure 5.1 Duct Efficiency provides the methodology in determining savings for sealing leaks in supply and return ducts of the HVAC distribution systems. To determine savings per the *CPS Energy Guidebook*, pre-improvement duct leakage and post-improvement duct leakage values are required. CPS Energy and Franklin Energy did not provide these values in their implementation of the Weatherization program. Frontier established an estimation method to determine duct system improvement savings for CPS Energy in the evaluations from previous years. This same methodology was applied for duct efficiency measures implemented by CPS Energy and Franklin Energy. In the future, Frontier would like to work with CPS Energy and Franklin Energy to require pre-improvement duct leakage measurements and post-improvement duct leakage measurements for each installation.

For the duct efficiency measures, Frontier assumed that 25% or more of the estimated linear feet of duct length would need to be sealed in order to be included in the savings estimate. Linear feet of duct length was estimated based on duct system assumptions in the *Building America Benchmark Definition*.[15]

To evaluate the impact of the duct sealing measures installed as part of the FY 2017 program, Frontier used field testing results from FY 2016 conducted for a sample of sixteen homes. Pre- and post-duct leakage-to-outside measurements were made using a Duct Blaster™ and blower door. For the homes in the sample, an average reduction of 17.3% in duct leakage to outside was measured. For each of the homes, the CFM leakage reduction estimate was derived by multiplying the home's CFM fan flow by the estimated 17.3% leakage reduction.

To better evaluate the energy savings of the duct sealing measures installed, Frontier recommends recording pre-improvement duct leakage and post-improvement duct leakage for each installation. The evaluation team will need to have additional discussions with CPS Energy and Franklin Energy to determine whether a total leakage testing approach will be allowed in place of the leakage-to-outside

[15] Building America Research Benchmark Definition, accessed on March 24, 2016 from http://www.nrel.gov/docs/fy10osti/47246.pdf

approach recommended by the *CPS Energy Guidebook*. Leakage rates must be measured and reported at the average air distribution system operating pressure (25 Pa). Frontier also recommends recording the heating type of the home and the cooling capacity of the home HVAC unit, as per the CPS Energy Guidebook.

3.6.2.12 Faucet Aerators

Through the Weatherization program, Franklin Energy installed 616 Faucet Aerators. CPS Energy did not include faucet aerators in their implementation of the Weatherization program. The Weatherization program includes the installation of two types of faucet aerators, one for a kitchen faucet and one for a bathroom faucet. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.1 Faucet Aerators. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet.

3.6.3 Results and Recommendations

The following are the gross energy and demand savings for the Weatherization program, by measure.

Table 3-11: Weatherization Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
CFLs	2,303	0.2	1.1	0.3
LEDs	2,060,534	194.3	1,023.4	305.3
Wall Insulation	2,629,963	1,324.1	2,686.9	1,246.0
Ceiling Insulation	4,990,079	2,976.6	4,939.8	2,671.7
Floor Insulation	71,767	4.2	126.8	5.3
Solar Screens	1,843,351	1,143.3	2,375.4	1,198.4
Water Heater Pipe Insulation	22,036	1.8	1.8	1.8
Water Heater Insulation	185,670	15.2	15.2	15.2
Showerheads	212,521	13.1	52.4	13.1
Air Infiltration	2,029,031	923.0	3,544.4	829.9
Duct Efficiency	373,875	87.8	95.7	81.9
Faucet Aerators	17,731	1.8	2.7	1.8
Total	**14,438,861**	**6,685.4**	**14,865.6**	**6,370.7**

Additionally, the following summarizes recommendations previously stated in earlier sections:

- Solar Screens – To reduce the potential error in the savings estimate resulting from this assumption, Frontier recommends that total square feet of solar screens installed per home be captured, in addition to united inches.
- Duct System Improvement – To better evaluate the energy savings of the duct sealing measures installed, Frontier recommends recording pre-improvement duct leakage and post-improvement duct leakage for each installation. The evaluation team will need to have additional discussions with CPS Energy and Franklin Energy to determine whether a total leakage testing approach will be allowed in place of the leakage-to-outside approach recommended by the CPS Energy Guidebook. Leakage rates must be measured and reported at the average air distribution system operating pressure (25 Pa). Frontier also recommends recording the heating type of the home and the cooling capacity of the home HVAC unit, as per the CPS Energy Guidebook.

3.7 RESIDENTIAL LIGHTING (LED) PROGRAM

3.7.1 Overview

In FY 2017, CPS Energy implemented a program to promote the adoption of LED lighting by handing out 9.5 Watt LEDs at Customer Care Fairs. The community fairs were target-marketed to the immediate area surrounding the location where CPS Energy held the event. The light output of 800 lumens is roughly equivalent to a conventional 60-watt incandescent A-lamp.

During the program year, 6,851 bulbs were handed out directly at Customer Care Fairs. Using a leakage rate of 10%, savings estimates are based on a total of 6,166 installed units.

3.7.2 Savings Calculation Method

Energy savings calculations are presented in the *CPS Energy Guidebook* under measure 4.3 ENERGY STAR® Omni-directional LED Lamps.

There is a two-step savings calculation for this measure, due to the baseline change that is scheduled to occur in 2020. The *CPS Energy Guidebook* also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Tiered savings are discounted by a rate of 3% to assume a 97% installation rate for upstream lighting programs.

Using a method to calculate the lifetime avoided cost benefit based on CPS Energy's projected avoided energy costs, a weighted average lifetime annual savings of 15.82 kWh per year is derived.

3.7.3 Results and Recommendations

For future iterations of this program, Frontier recommends a verification system at the community fairs to confirm that the attendee has a CPS Energy Customer Account or a residence within CPS Energy's service territory before receiving the LED bulb. Depending on the level of rigor involved, the results of this type of review could be used to reduce or eliminate the current 10% leakage assumption.

The following are the gross energy and demand savings for the Residential Lighting program.

Table 3-12: Residential Lighting (LED) Gross Energy and Demand Saving

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Residential LED	97,548	9.469	48.470	14.834

3.8 HOME ENERGY ASSESSMENT

3.8.1 Overview

The Home Energy Assessment (HEA) Program provides energy-saving products to CPS Energy customers by means of an in-person home energy assessment or through home energy assessment direct installation kits. The home energy assessment program provided installations and kits in 2,548 homes in FY 2017.

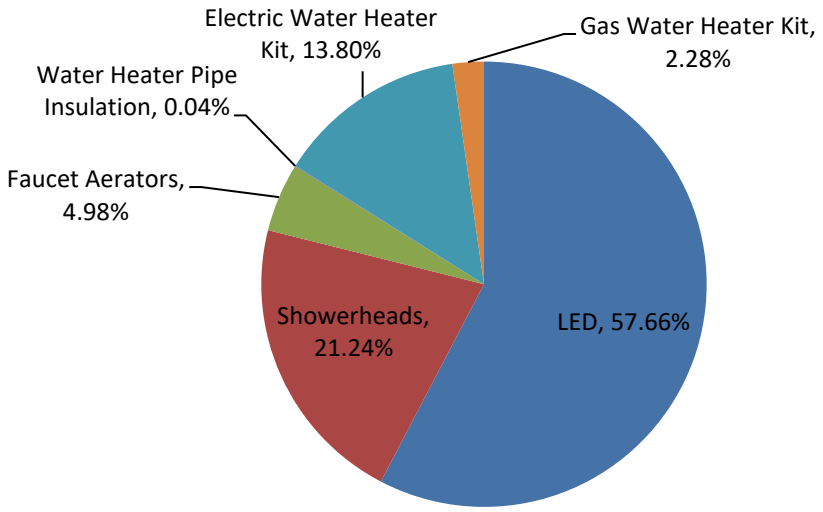

Figure 3-13: Home Energy Assessment Program – kWh by Measure

3.8.2 Savings Calculation Method

The energy and demand savings for the HEA Program were determined using the methodologies outlined in the *CPS Energy Guidebook*. The sections below include the savings methodologies for in-person installations for LED light bulbs, low-flow showerheads, faucet aerators, and water heater pipe insulation. The following sections also include the savings methodologies for the two HEA kits, one for electric water heater customers and one for gas water heater customers.

3.8.2.1 LED Light Bulbs

The HEA program includes the installation of LED lighting, consisting of LED lamps, LED flood lights, LED globes, and LED candelabras. Through the HEA program, 36,776 bulbs were installed. The energy and demand savings are determined using the CPS Energy Guidebook measure 4.3 ENERGY STAR® Omni-directional LED lamps and 4.4 ENERGY STAR® specialty and directional LED lamps. Coincident, non-coincident, and 4CP peak demand factors were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes.

EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Savings are discounted by a rate of 3% to assume a 97% installation rate for upstream lighting programs.

3.8.2.2 Low-Flow Showerheads

The HEA program includes the installation of 1,446 low-flow showerheads. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.2 Showerheads. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead.

3.8.2.3 Faucet Aerators

The Home Energy Assessment program includes the installation of two types of faucet aerators, one for a kitchen faucet and one for a bathroom faucet. Through this program, CPS Energy installed 614 kitchen aerators and 1,499 bathroom aerators for a total of 2,113 faucet aerators. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.1 Faucet Aerators. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet.

3.8.2.4 Water Heater Pipe Insulation

The Home Energy Assessment program includes installations of water heater pipe insulation in 43 homes. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.3 Pipe Insulation. Coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

The savings are based on an assumed baseline of a typical electric water heater without insulation on the water heater pipes. Savings for water heater pipe insulation are based on a maximum allowable insulation length of 6 feet of piping, as per the *CPS Energy Guidebook*. For any installation of water heater pipe insulation over six feet, the savings were capped at this maximum.

3.8.2.5 Home Energy Assessment Kit: Electric Water Heater Customers

Through the Home Energy Assessment program, CPS Energy also offered the option of direct installation kits for customers. 776 kits were distributed to electric water heater customers. The electric water

heater kit consists of five 9-Watt LED lightbulbs, one low-flow showerhead, one kitchen faucet aerator, one bathroom faucet aerator, and six feet of pipe insulation.

The savings methodology for each of these measures is demonstrated above. An installation rate is applied to the savings for each of these measures. These installation rates were provided by the contractor through a data analysis installation document. The installation rates for LEDs are 95% for the first LED, 90% for the second LED, 85% for the third LED, 80% for the fourth LED, and 75% for the fifth LED. The low-flow showerheads were evaluated using an installation rate of 65%. The savings for kitchen faucet aerators were determined using a 72% installation rate and savings for bathroom aerators were determined using a 71% installation rate. The savings for pipe insulation were determined using a 50% installation rate.

3.8.2.6 Home Energy Assessment Kit: Gas Water Heater Customers

Through the Home Energy Assessment program, CPS Energy also offered the option of direct installation kits for customers. 594 kits were distributed to gas water heater customers. The gas water heater kit consists of five 9-Watt LED lightbulbs.

The savings methodology for the LED lighting is demonstrated above. An installation rate is applied to the savings for each of the light bulbs in the kit. These installation rates were provided by the contractor through a data analysis installation document. The installation rates for LEDs are 95% for the first LED, 90% for the second LED, 85% for the third LED, 80% for the fourth LED, and 75% for the fifth LED.

3.8.3 Results and Recommendations

For future iterations of the Home Energy Assessment program, Frontier recommends conducting customer surveys for the electric water heater kits and gas water heater kits. Using survey data, more accurate installation rates can be applied.

The following are the gross energy and demand savings for the Home Energy Assessment program.

Table 3-13: Home Energy Assessment Gross Energy and Demand Saving

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
LED	1,038,902	100.8	516.2	158.0
Showerheads	382,696	23.6	94.3	23.6
Faucet Aerators	89,640	9.0	13.8	9.0
Water Heater Pipe Insulation	804	0.1	0.1	0.1
Electric Water Heater Kit	248,611	19.2	67.6	22.2
Gas Water Heater Kit	40,991	4.0	20.4	6.2
Home Energy Assessment Program	**1,801,644**	**156.7**	**712.4**	**219.1**

3.9 MULTIFAMILY ENERGY EFFICIENCY

3.9.1 Overview

The Multifamily Energy Efficiency program provides energy efficient measures to multifamily property with more than five units. The Multifamily program includes installation of LED bulbs, high-efficiency showerheads, kitchen and bathroom faucet aerators, and water heater pipe insulation.

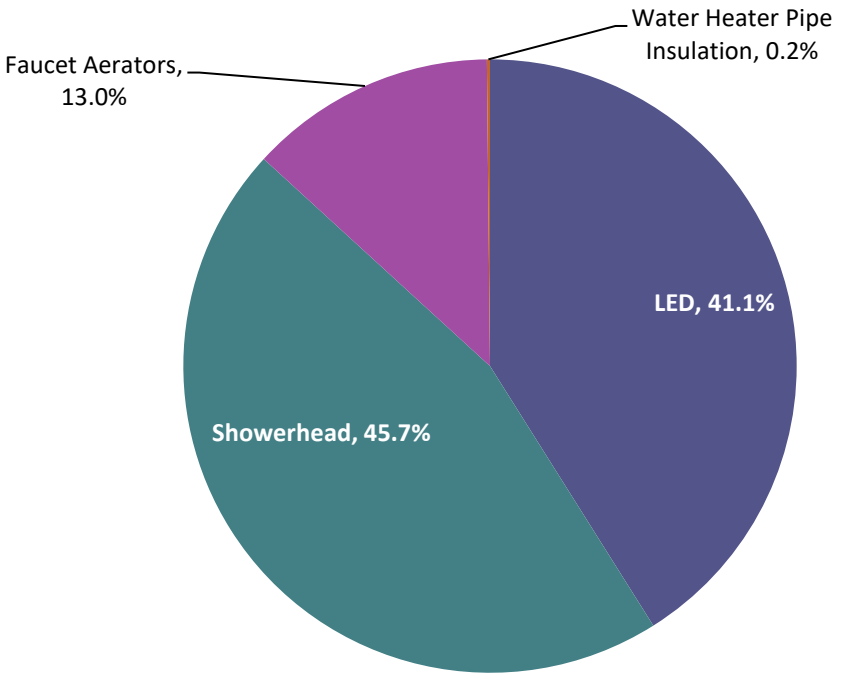

Figure 3-14: Multifamily Program – kWh by Measure

3.9.2 Savings Calculation Method

The energy and demand savings for the Multifamily program were determined using the methodologies outlined in the *CPS Energy Guidebook*.

3.9.2.1 LED Light Bulbs

The Multifamily program includes the installation of 25,013 LED bulbs, consisting of LED Lamps, LED Flood Lights, LED Globes, and LED Candelabras. The energy and demand savings are determined using the CPS Energy Guidebook measure 4.3 ENERGY STAR® Omni-directional LED Lamps and 4.4 ENERGY STAR® Specialty and Directional LED Lamps. Coincident, non-coincident, and 4CP peak demand factors were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes.

EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads. Savings are discounted by a rate of 3% to assume a 97% installation rate for lighting programs.

3.9.2.2 Low-Flow Showerheads

The Multifamily Energy Efficiency program includes the installation of 1,803 low-flow showerheads. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.2 Showerheads. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead.

3.9.2.3 Faucet Aerators

The Multifamily Energy Efficiency program includes the installation of two types of faucet aerators, one for a kitchen faucet and one for a bathroom faucet. Through this program, CPS Energy installed 1,695 kitchen aerators and 1,818 bathroom aerators for a total of 3,513 faucet aerators. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.1 Faucet Aerators. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet.

3.9.2.4 Water Heater Pipe Insulation

The Multifamily Energy Efficiency program includes 291 installations of water heater pipe insulation. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.3 Pipe Insulation. Coincident, non-coincident, and 4CP peak demand factors were calculated using an assumption that the load shape for this measure is evenly distributed across all hours of the year.

The savings are based on an assumed baseline of a typical electric water heater without insulation on the water heater pipes. Savings for water heater pipe insulation are based on a maximum allowable insulation length of 6 feet of piping, as per the Guidebook. For any installation of water heater pipe insulation over six feet, the savings were capped at this maximum.

3.9.3 Results and Recommendations

The following are the gross energy and demand savings for the Multifamily Energy Efficiency program.

Table 3-14: Multifamily Gross Energy and Demand Saving

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
LED	428,417	41.6	212.9	65.1
Showerhead	477,179	29.4	117.6	29.4
Faucet Aerators	136,071	13.6	21.0	13.6
Water Heater Pipe Insulation	1,695	0.1	0.1	0.1
Multifamily Total	**1,043,361**	**84.7**	**351.6**	**108.2**

3.10 SCHOOL2HOME

3.10.1 Overview

The School2Home Program provides students with energy efficiency kits. The kits are comprised of three 9-Watt LED light bulbs, a high-efficiency showerhead, a kitchen faucet aerator, and a bathroom faucet aerator. 12,420 kits were distributed at 66 schools in FY 2017.

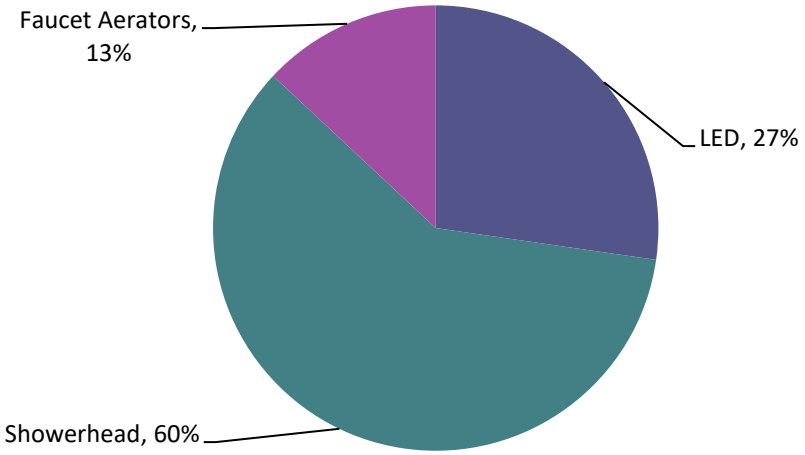

Figure 3-15: School2Home Program – kWh by Measure

3.10.2 Savings Calculation Method

The energy and demand savings for the School2Home Program kits were determined using the methodologies outlined in the *CPS Energy Guidebook*. The installation rates for the kits were derived from the student survey data for the program.

3.10.2.1 LED Light Bulbs

The School2Home kit includes three 9-Watt LED light bulbs. The energy and demand savings are determined using the *CPS Energy Guidebook* measure 4.3 ENERGY STAR® Omni-directional LED Lamps. Coincident, non-coincident, and 4CP peak demand factors were calculated using a residential lighting load profile developed from the Building America Analysis spreadsheet for existing homes. There is a two-step savings calculation for this measure, due to the baseline change that is scheduled to occur in 2020. The Guidebook also incorporates an interactive effects factor to account for the impacts on cooling and heating loads.

Installation rates were derived from the student survey data. From the student survey data, 66% of families installed the first LED light bulb, 56% of families installed the second LED light bulb, and 49% of families installed the third LED light bulb.

3.10.2.2 Low-Flow Showerheads

The School2Home kit includes one low-flow showerhead. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.2 Showerheads. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.5 gallon per minute (GPM) flowrate for the existing showerhead and a 1.5 GPM flowrate for the replacement showerhead.

Installation rates were derived from the student survey data. From the student survey data, 51% of families installed the high-efficiency showerhead.

3.10.2.3 Faucet Aerators

The School2Home kit includes two faucet aerators, one for a kitchen faucet and one for a bathroom faucet. The energy and demand savings are determined using the algorithms in the *CPS Energy Guidebook* measure 7.1 Faucet Aerators. Coincident, non-coincident, and 4CP peak demand factors were calculated using a DHW load profile developed from the Building America Analysis spreadsheet for existing homes.

Savings for this measure are determined using a baseline assumption of a 2.2 gallon per minute (GPM) flowrate for the existing faucets. The savings for aerators are based on an assumed 1.5 GPM flowrate for the post-retrofit kitchen faucet and an assumed 1.0 GPM flowrate for the post-retrofit bathroom faucet.

Installation rates were derived from the student survey data. From the student survey data, 39% of families installed the new kitchen faucet aerator and 38% of families installed the new bathroom aerator.

3.10.3 Results and Recommendations

The following are the gross energy and demand savings for the School2Home program.

Table 3-15: School2Home Gross Energy and Demand Saving

Measure	Energy Savings (kWh)	Non-Coinc. Demand Savings (kW)	Peak Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
LED	344,854	171.3	33.5	52.4
Showerhead	754,379	185.9	46.5	46.5
Faucet Aerators	164,705	25.4	16.5	16.5
Total	**1,263,938**	**382.6**	**96.4**	**115.4**

3.11 RESIDENTIAL RETAIL PARTNERS

3.11.1 Overview

The Residential Retail Partners program offers in-store rebates for ENERGY STAR® certified lighting. There are 72 participating retailers in this program and rebates were offered for 66 different types of lighting. A total of 76,657 bulbs were incentivized under this program in FY 2017.

3.11.2 Savings Calculation Method

Savings for this program were determined using the *CPS Energy Guidebook* methodology for ENERGY STAR® Omni-Direction LED Lamps and for ENERGY STAR® Specialty and Directional LED Lamps.

EISA-affected bulbs had savings that were determined using a two-tiered weighting approach due to the baseline change that is scheduled to occur in 2020. The savings for EISA-exempt bulbs were determined over the entire lifetime of the bulb using the equivalent wattages.

The *CPS Energy Guidebook* also incorporates an interactive effects factor to account for the impacts on cooling and heating loads.

3.11.3 Results and Recommendations

The following are the gross energy and demand savings for the Residential Retail Partners program.

Table 3-16: Residential Retail Partners Gross Energy and Demand Saving

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
LED	1,561,620	151.6	775.9	237.5

4. COMMERCIAL PROGRAMS

4.1 SUMMARY OF COMMERCIAL IMPACTS

CPS Energy offered the following programs for the Commercial sector in FY 2017:

- Commercial Large Lighting - offers incentives to customers who install efficient lighting in their facilities. Incentives are offered for both retrofit and new construction projects.
- Commercial HVAC - offers incentives for the installation of high efficiency unitary AC equipment, heat pump and chillers.
- Commercial Custom - provides a comprehensive platform for cost–effective efficiency measures not addressed by the other commercial rebate offerings.
- Commercial New Construction - offers incentives to developers to build at least 15% more energy efficient than current CoSA building codes.
- C&I Solutions - energy assessment program focusing on helping business customers identify opportunities and rebate offerings for energy efficiency measures including lighting, HVAC, and refrigeration.
- Schools & Institutions - focuses on helping schools and government agencies reduce energy use through benchmarking, technical assistance, energy master planning workshops, and rebate offerings for energy efficiency measures.
- Small Business Solutions - a contractor led incentive program for energy efficiency measures for small business customers with less than 100 kW demand.
- Whole Building Optimization - offers contractor led incentives for building optimization, which includes tools and strategies to enhance a facility's operational efficiency.

CPS Energy's portfolio of commercial programs addresses most markets and major commercial end uses.

To evaluate energy impacts for most program measures, Frontier utilized the *CPS Energy Guidebook*. For programs or measures where other methods were used, those are referenced in each section.

Except where noted, coincident peak values were calculated using the weighted-average 20-hour probability method, as outlined in Section 2.2.

All values in the tables and charts throughout this section represent energy and demand savings from new FY 2017 program participants as measured at the participant or end-user level. These savings are

adjusted in the program portfolio rollup table in the Executive Summary and in benefit-cost calculations to account for net-to-gross ratios and distribution line losses[16].

The contribution of each commercial program to the portfolio's energy, peak demand and non-coincident peak savings are shown in the following charts.

Some programs were implemented by CLEAResult under contract to CPS Energy and started more than halfway through CPS Energy's fiscal year. As such, program costs reported herein may include extra costs associated with startup, and energy savings and benefits may be lower than expected due to lower levels of participation in the early ramping stage of program implementation. The costs include one-time startup expenses while the savings only represent the first 4 months of program activity due to program launch date of 9/1/2016. Benefit-cost results reported here should be interpreted within this context. Future evaluations are planned to cover full contractual and fiscal years, and which should yield results that are more directly comparable with past evaluations.

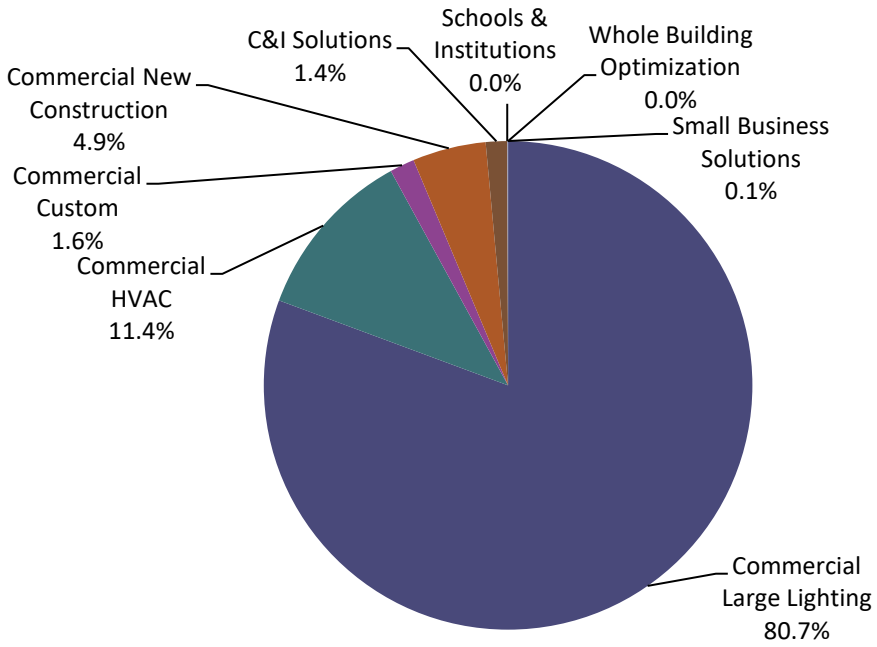

Figure 4-1: Summary of Commercial Impacts – Coincident kW by Program

[16] Net-to-gross (NTG) ratios are estimated at the level of individual programs, and account for the net effects of free ridership and spillover. Free riders are defined as customers who would have delivered energy or demand savings without any program incentives but who received a financial incentive or rebate anyway. Spillover effects derive from customers who delivered energy or demand savings because of the program, but did not participate in the program or receive a financial incentive or rebate. Distribution line losses account for the fact that utilities must generate or import a greater amount of energy or demand than is required at the customer or end-user level because some energy is lost on the distribution system.

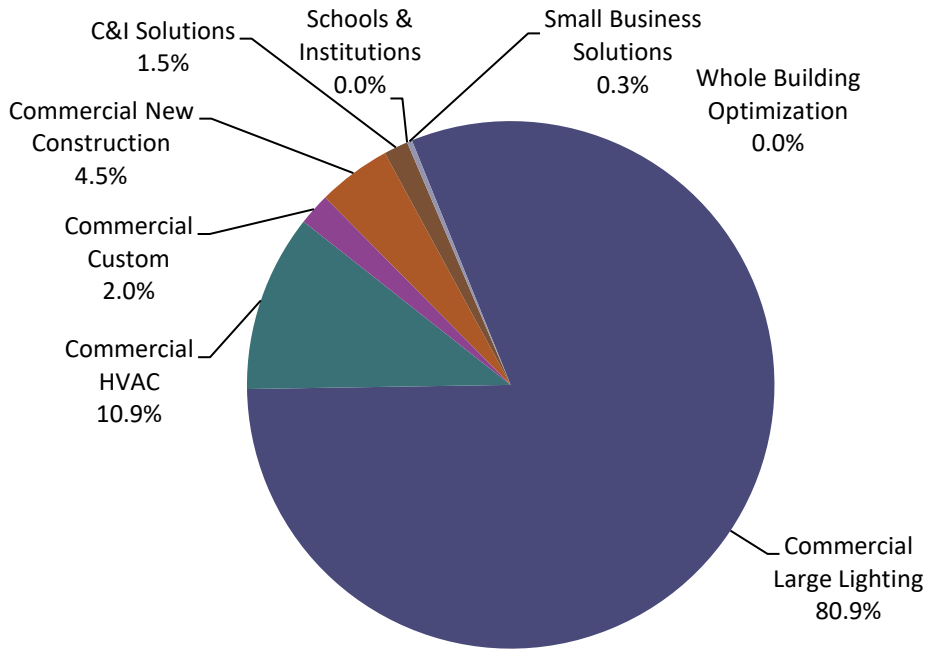

Figure 4-2: Summary of Commercial Impacts – Non-Coincident kW by Program

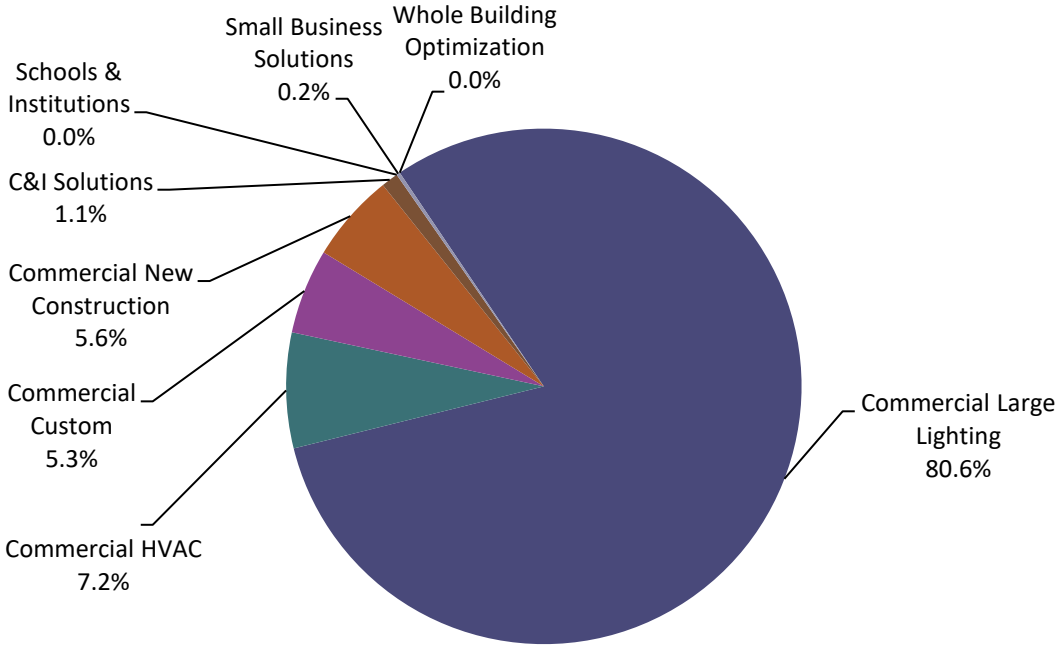

Figure 4-3: Summary of Commercial Impacts – kWh by Program

4.2 COMMERCIAL LIGHTING PROGRAM

4.2.1 Overview

This program includes the installation of energy-efficient lighting and lighting controls. In FY 2017, a total of 656 lighting and/or lighting controls projects were incentivized through the CPS Energy Commercial Lighting program. This represents a 6% decrease from the 699 projects completed in FY 2016. However, this program was only offered for a seven month period before transitioning to different program offerings implemented by CLEAResult. Extrapolating these projects over the course of 12 months yields a projected project total of approximately 1,125 projects, indicating that the program was on pace to increase participation by 61%.

The figures below present percentage breakdowns of kWh energy savings by fixture type and building type for sampled lighting projects completed through this program.

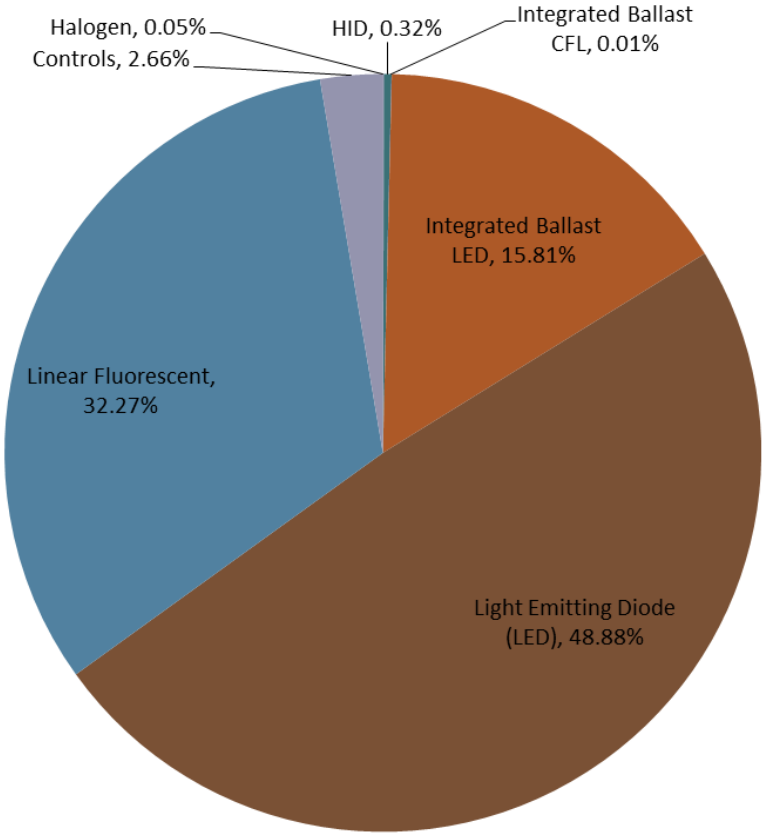

Figure 4-4: CPS Energy Commercial Lighting – Percent of kWh Savings by Fixture Type for Sampled Projects

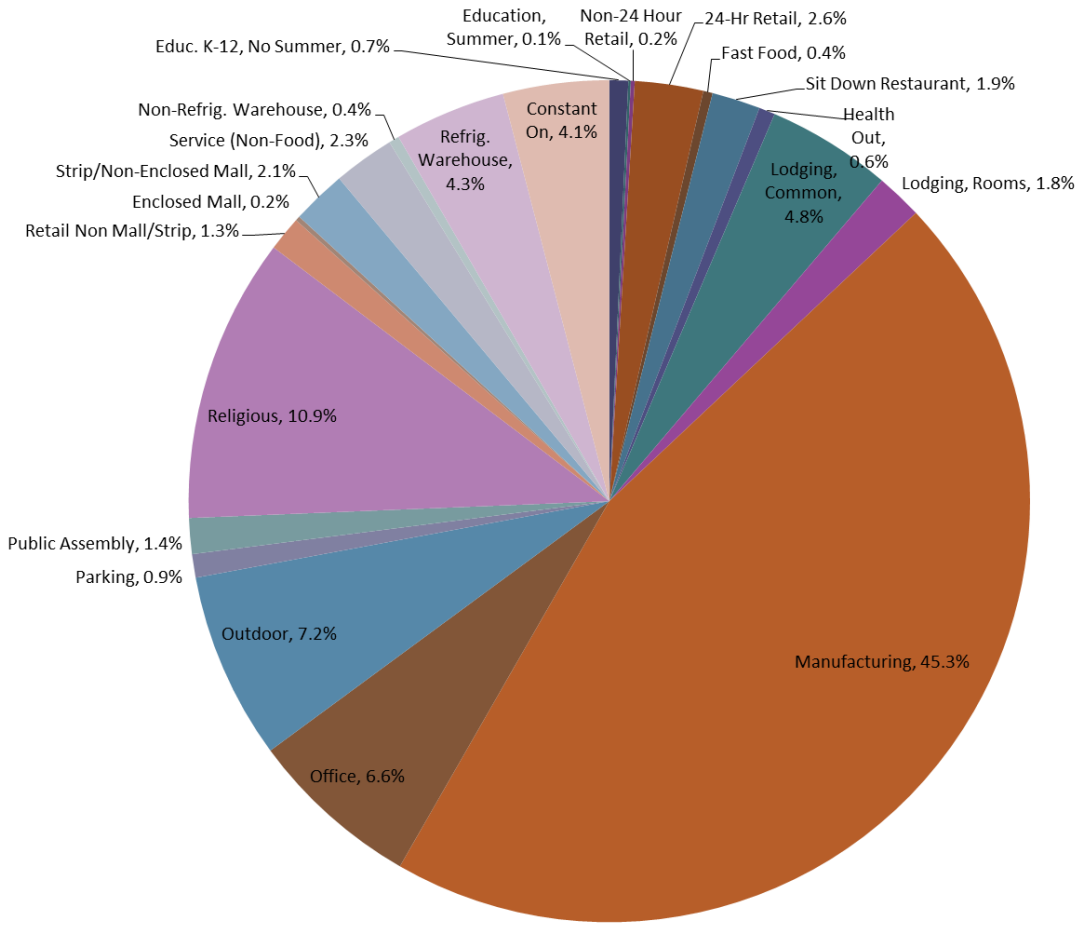

Figure 4-5: CPS Energy Commercial Lighting - Percent of kWh Savings by Building Type for Sampled Projects

4.2.2 Savings Calculation Method

A desk review was performed for a sample projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were then applied to the full project population.

Frontier randomly selected a sample of 31 lighting projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. The savings calculation is different for new construction and retrofit project. General savings algorithms are specified below. For retrofit projects, the savings are represented by the change in existing and installed wattage with the inclusion of applicable adjustment factors. For new construction projects, the savings are calculated based on the difference of the installed wattage and a per square foot lighting power allowance that is specified for various building types (referred to as the lighting power density, or LPD). Refer to the *CPS Energy Guidebook* for a detailed overview of the savings methodology used to evaluate this measure.

Retrofit:

$$Peak\ Demand\ Savings = (kW_{pre} - kW_{installed}) \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = (kW_{pre} - kW_{installed}) \times Hours \times HVAC_{energy}$$

New Construction:

$$Peak\ Demand\ Savings = \left(\frac{LPD \times Floor\ Area}{1{,}000} - kW_{installed}\right) \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = \left(\frac{LPD \times Floor\ Area}{1{,}000} - kW_{installed}\right) \times Hours \times HVAC_{energy}$$

First, claimed pre/post fixture counts and wattages were verified against project documentation. Hours of operation and demand factors were also verified against the reported building type.

For lighting installed in a conditioned space, Frontier awarded additional savings to account for HVAC/refrigeration interactive effects of the projects. A reduced lighting load reduces the internal heat gain to the building, which reduces the cooling load but increases the heating load. In order to estimate interactive effects for high-efficiency lighting installed in conditioned spaces, Frontier applied the following deemed interactive effects factors to the applicable projects:

Table 4-1: Commercial Lighting HVAC Interactive Effects Factors

Space Cooling Type	$HVAC_{demand}$ Factor	$HVAC_{energy}$ Factor
Air Conditioned	1.10	1.05
Medium Temperature Refrigeration (33 to 41°F)	1.25	1.25
Low Temperature Refrigeration (-10 to 10°F)	1.30	1.30
None (Unconditioned)	1.00	1.00

The non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand factors used to estimate demand savings for this measure were derived using an approach adapted from the method outlined in Section 2.3 of the *CPS Energy Guidebook*. First, lighting schedules were extracted from BEopt energy simulation models developed for the commercial HVAC measures based on Department of Energy (DOE) commercial reference buildings.[17] Next, hourly percentages of lighting in operation were extracted from the lighting schedules. The resulting lighting factors were weighted using

[17] DOE Commercial Reference Buildings: http://energy.gov/eere/buildings/commercial-reference-buildings.

the probabilities assigned to each of the top 20 peak hours and 4CP hours. NCP factors match the maximum lighting factor from the lighting schedule for each building type.

After the inclusion of HVAC interactive effects, it is possible that the CP or 4CP verified savings would exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project.

Existing lighting controls were used to reduce the deemed demand factors and operating hours used to calculate the baseline power and energy usage for existing lighting equipment. For installed lighting controls, savings were calculated by applying a deemed savings factor against the installed wattage.

$$Peak\ Demand\ Savings = kW_{controlled} \times Control\ Savings\ Factor \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = kW_{controlled} \times Control\ Savings\ Factor \times Hours \times HVAC_{energy}$$

The deemed control savings factors are presented in the following table:

Table 4-2: Lighting Controls – Savings Factors[18]

Control Type	Sub-Category	Savings Factor
None	n/a	0.00
Occupancy	n/a	0.24
Daylighting (Indoor)	Continuous dimming	0.28
	Multiple step dimming	
	ON/OFF	
Outdoor19	n/a	0.00
Personal Tuning	n/a	0.31
Institutional Tuning	n/a	0.36
Multiple/Combined Types	Various combinations	0.38

[18] Williams, Alison, Atkinson, Barbara, Garbesi, Karina, & Rubinstein, Francis, "A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings". Lawrence Berkeley National Laboratory. September 2011. Table 6, p. 14. Weighted average by number of "reviewed" and "non reviewed" papers.

[19] No control savings are allowed for outdoor controls because they are already required by code. ASHRAE 90.1-1989, Section 6.4.2.8 specifies that exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell, or a combination of timer and photocell. This is consistent with current specifications in ASHRAE 90.1-2010, Section 9.4.1.3, which specifies that lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours.

4.2.3 Results and Recommendations

A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the projects sampled for a desk review. The weighted average realization rates were then applied to the entire project population (both sampled and un-sampled).

The weighted average realization rate for the lighting and lighting controls projects were 103.7% for NCP kW demand savings and 107.6% for kWh energy savings. The weighted average estimated useful life (EUL) applied to the verified savings was 14.0 years.

While the recommendations for commercial lighting measures in previous evaluations focused heavily on data collection, that direction is no longer necessary because this measure is no longer implemented directly by CPS Energy. For relevant recommendations, please refer to the sections for the CLEAResult C&I Solutions, Schools and Institutions, and Small Business Solutions programs.

Table 4-3: CPS Energy Commercial Lighting Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Non-Coincident kW Savings	Annual Coincident Peak kW Savings	TCOS 4CP kW Savings
Commercial Lighting	129,607,475	23,707.19	20,790.95	20,693.84

4.3 COMMERCIAL HVAC PROGRAM

4.3.1 Overview

CPS Energy's Commercial Heating, Ventilation, and Air Conditioning (HVAC) program offers incentives to promote the installation of energy efficient HVAC equipment. The program covers the installation of split/unitary air conditioners and heat pumps (ACs/HPs), packaged terminal air conditioners and heat pumps (PTACs/PTHPs), and air/water cooled water chilling packages (chillers).

The program had 97 unique project sites in FY 2017, including 286 direct expansion (DX) split/unitary ACs, 4 DX split/unitary HPs, 247 PTACs, 35 air cooled chillers (ACCs), and 35 water cooled chillers (WCCs) for a total of 607 installed HVAC systems. This corresponds to a 31% increase in unique project sites and a 126% increase in total HVAC systems installed compared to FY 2016. Total tonnage installed for all projects was 25,332 tons of equipment for all system types. However, this program was only offered for a seven month period before transitioning to different program offerings implemented by CLEAResult. Extrapolating these projects over the course of 12 months yields a projected unique project site total of approximately 166 sites and a projected number of installed HVAC systems of approximately 1,041 systems.

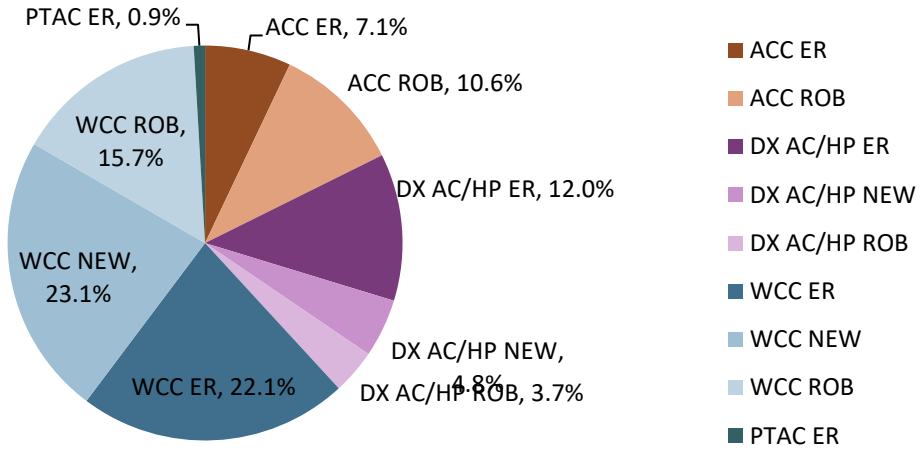

Figure 4-6: Commercial HVAC – Percentage of Total Tonnage for New Construction (NC), Replace-on-Burnout (ROB), and Early Retirement (ER) Projects by Equipment Type

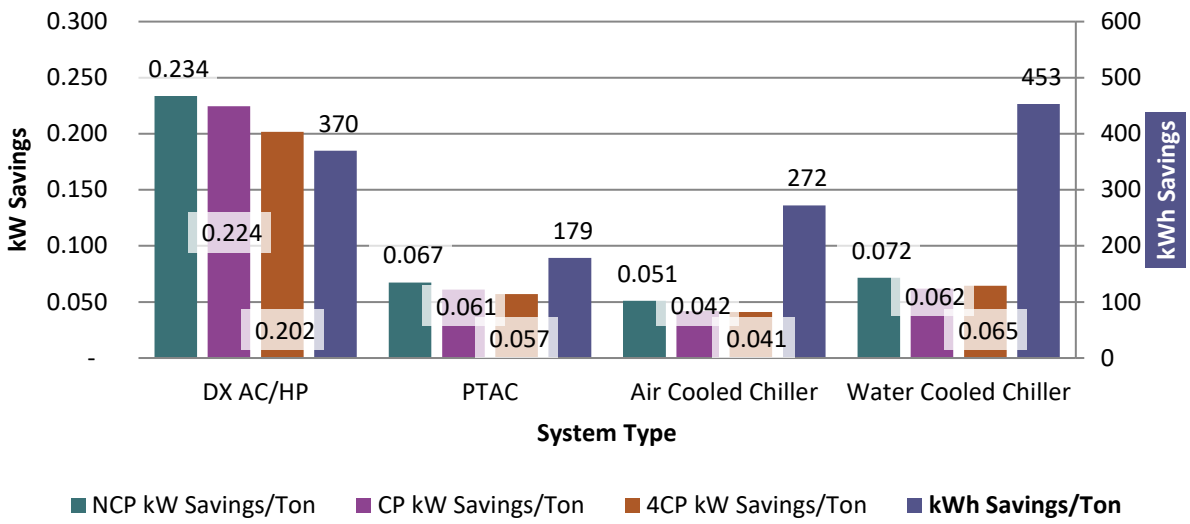

Figure 4-7: Commercial HVAC – Average Demand and Energy Savings per Ton by Equipment Type

4.3.2 Savings Calculation Method

Energy and demand savings were estimated using algorithms developed by Frontier for the *CPS Energy Guidebook*. This method incorporates part-load efficiencies for the purposes of calculating energy savings as well as heating energy savings derived from the methodology previously specified in Texas TRM v. 4.0 but adapted for CPS Energy. In order to calculate energy savings for this measure in the *CPS Energy Guidebook*, Frontier used weather-specific assumptions for San Antonio instead of a regional climate zone. Frontier used equivalent full-load hour assumptions developed using energy models that have been updated for incorporation into Texas TRM v. 4.0. These models were adjusted to use the San Antonio weather file in order to develop a new climate zone that is regionally specific to the CPS Energy service territory.

Baseline equipment efficiencies for new construction (NC) and replace-on-burnout (ROB) projects were assumed to be IECC 2015 for all system types in accordance with the current commercial energy code for the city of San Antonio.[20] This is a change from previous program years that used IECC 2009 as the baseline for equipment efficiencies.

Early retirement (ER) projects were allowed a dual-baseline weighted according to the estimated remaining useful life (RUL) of the existing equipment and EUL for the installed equipment.

[20] U.S. Department of Energy (DOE): Energy Codes by State. http://www.energycodes.gov/adoption/states.

Table 4-4: Commercial HVAC – Dual-Baseline for Early Retirement Projects

Baseline Period	Effective Baseline Code
RUL	Varies based on manufacture year of existing equipment
EUL - RUL	IECC 2015

Table 4-5: Commercial HVAC – Average Manufacture Year of Replaced Equipment from Early Retirement by System Type

System Type	Average Year
Split/Unitary AC, HP, PTAC, and PTHP	1999
Air Cooled Chillers	2000
Water Cooled Chillers	1992

4.3.2.1 Unitary AC Equipment

Savings algorithms from FY2017 CPS Energy Guidebook were used to estimate energy savings using part-load system efficiency.

$$Cooling\ kWh\ Savings = \left(\frac{Cap_{C,pre}}{SEER/IEER_{baseline}} - \frac{Cap_{C,post}}{SEER/IEER_{installed}}\right) \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C$$

$$Heating\ kWh\ Savings = \left(\frac{Cap_{H,pre}}{HSPF/COP_{baseline}} - \frac{Cap_{H,post}}{HSPF/COP_{installed}}\right) \times \frac{1\ kWh}{3{,}412\ Btu} \times EFLH_H$$

Where:

Cap_C = Rated equipment cooling capacity of existing/installed equipment (Btuh)

Cap_H = Rated equipment heating capacity of existing/installed equipment (Btuh)

$SEER/IEER_{baseline}$ = Deemed part-load cooling efficiency of existing equipment

$SEER/IEER_{installed}$ = Rated part-load cooling efficiency of installed equipment

$HSPF/COP_{baseline}$ = Deemed heating efficiency of existing equipment

$HSPF/COP_{installed}$ = Rated heating efficiency of installed equipment

$EFLH_C$ = Deemed equivalent full-load cooling hours

$EFLH_H$ = Deemed equivalent full-load cooling hours

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, non-coincident peak (NCP) demand savings were determined by identifying the maximum demand reduction during the entire year. Coincident peak (CP) demand savings were calculated according to the procedure outlined in Section 2.2. ERCOT 4CP Transmission cost savings were calculated using the procedure outlined in Section 2.4.2.

4.3.2.2 Packaged Terminal Air Conditioners and Heat Pumps (PTAC/PTHPs)

Savings algorithms from the *CPS Energy Guidebook* were used to estimate energy savings using full-load system efficiency. Full-load efficiencies were used because PTACs do not have a part-load efficiency rating.

$$Cooling\ kWh\ Savings = \left(\frac{Cap_{C,pre}}{EER_{baseline}} - \frac{Cap_{C,post}}{EER_{installed}}\right) \times \frac{1\ kW}{1{,}000\ W} \times EFLH_C$$

$$Heating\ kWh\ Savings = \left(\frac{Cap_{H,pre}}{COP_{baseline}} - \frac{Cap_{H,post}}{COP_{installed}}\right) \times \frac{1\ kWh}{3{,}412\ Btu} \times EFLH_H$$

Where:

Cap_C = Rated equipment cooling capacity of existing/installed equipment (Btuh)

Cap_H = Rated equipment heating capacity of existing/installed equipment (Btuh)

$EER_{baseline}$ = Deemed full-load cooling efficiency of existing equipment

$EER_{installed}$ = Rated full-load cooling efficiency of installed equipment

$COP_{baseline}$ = Deemed heating efficiency of existing equipment

$COP_{installed}$ = Rated heating efficiency of installed equipment

$EFLH_C$ = Deemed equivalent full-load cooling hours

$EFLH_H$ = Deemed equivalent full-load cooling hours

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, NCP demand savings were determined by identifying the maximum demand reduction during the entire year. CP demand savings were calculated according to the procedure outlined in Section 2.2. ERCOT 4CP demand savings were calculated using the procedure outlined in Section 2.4.2.

4.3.2.3 Air and Water Cooled Chillers

Savings algorithms from the *CPS Energy Guidebook* were adjusted to estimate energy savings using part-load system efficiency.

$$Cooling\ kWh\ Savings = Capacity \times \left(Cap_{C,pre} \times IPLV_{baseline} - Cap_{C,post} \times IPLV_{installed}\right) \times EFLH_C$$

Where:

Cap_C = Rated equipment cooling capacity of existing/installed equipment (tons)

$IPLV_{baseline}$ = Deemed part-load cooling efficiency of existing equipment (kW/ton)

$IPLV_{installed}$ = Rated part-load cooling efficiency of installed equipment (kW/ton)

$EFLH_C$ = Deemed equivalent full-load cooling hours

Any integrated part-load values (IPLV) rated in EER have been converted to kW/ton using the following conversion:

$$\frac{kW}{ton} = \frac{12}{EER}$$

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, NCP demand savings were determined by identifying the maximum demand reduction during the entire year. CP demand savings were calculated according to the procedure outlined in Section 2.2. ERCOT 4CP demand savings were calculated using the procedure outlined in Section 2.4.2.

4.3.3 Equipment Verification

To verify the accuracy of the efficiency data listed in the program database, Frontier reviewed reported equipment information including building type, project type, system type, system count, system capacity, full/part-load cooling efficiency, and heating efficiency against project invoices, manufacturer specification sheets, and equipment information maintained by the Air Conditioning, Heating, and Refrigeration Institute (AHRI).[21]

For reviewed split/unitary AC and HP installation, the reported cooling/heating capacity and full/part-load efficiencies were compared against available AHRI data. For reviewed chiller installation, the reported capacity and full/part-load efficiencies were compared against manufacturer specification sheets, referencing ratings at AHRI conditions whenever available. Reported system types, counts, capacities, and efficiencies were adjusted as necessary based on this review.

4.3.4 Results and Recommendations

Total verified energy and demand savings for the installation of split/unitary ACs and HPs, PTACs/PTHPs, and chillers are included in the following table.

Table 4-6: Commercial HVAC – Gross Energy and Demand Savings

[21] AHRI Certification Directory: https://www.ahridirectory.org/ahridirectory/pages/home.aspx.

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial HVAC	10,311,343	2,823	2,598	2,501

- While the recommendations for commercial HVAC measures in previous evaluations have focused on data collection, that direction is no longer necessary because this measure is no longer implemented directly by CPS Energy. For relevant recommendations, please refer to the sections for the CLEAResult C&I Solutions, Schools and Institutions, and Small Business Solutions programs.

4.4 COMMERCIAL CUSTOM PROGRAM

4.4.1 Overview

In FY 2017, CPS Energy offered incentives for commercial custom measures at $0.08/kWh and $200/kW. There were a total of nine custom projects totaling $664,742 in incentives. The nine custom projects were reviewed by Frontier both upon application submittal and again before rebate approval.

This program's internal review process, revised in FY 2013, was continued during the course of FY 2017. Customers were required to submit explanations for their projected savings, along with equipment information. Each project was reviewed individually, and an appropriate measurement and verification (M&V) plan was developed and provided to the customer. M&V was performed both before and after installation of new equipment, providing a high level of confidence in the calculation of actual energy savings achieved on each project.

4.4.2 Savings Calculation Method

Frontier completed an in-depth review of project documentation and savings estimates for each custom project to determine the reasonableness of savings estimates. A combination of measured data and manufacturer specifications was generally used, along with data collected from site visits, engineering estimations and assumptions where appropriate. Savings algorithms followed sound engineering principles and followed standard industry procedures for each given application.

The approximate M&V approach for each type of project is summarized in Table 4-7.

Table 4-7: Commercial Custom Program M&V Approach

Measure Type	Count of Projects	Approximate M&V Approach
ECM Motors	2 projects	IPMVP Option A – Retrofit Isolation
RTU Controls	1 project	IPMVP Option A – Retrofit Isolation
Refrigeration	3 projects	Spreadsheet based calculation using DOE calculated daily energy consumption methods.
Retrocommissioning (RCx)	2 projects	Spreadsheet based calculation using industry standard algorithms and trend data from building automation control system. Approximates IPMVP Options A and B – Retrofit Isolation
Data Center Cooling	1 project	Manufacturer derived savings estimates completed using industry standard algorithms and site specific design conditions. Savings verification completed using a combination of site meter data and engineering estimations.

As in previous years, retro-commissioning continues to provide a significant source of energy savings. Although it offers non-coincident peak savings, it does not contribute to coincident peak demand impacts. In FY 2017, the data center cooling project offered the most coincident peak savings. These

savings were delivered through a re-design of standard data center cooling strategy that utilizes close-coupled, refrigerant-based cooling delivered directly to each rack.

4.4.3 Results and Recommendations

The gross energy and demand savings calculated for the Commercial Custom Program are listed in Table 4-8 and depicted in Figure 4-8 and Figure 4-9.

Table 4-8: Commercial Custom Program Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial Custom	7,288,393	359	487	325

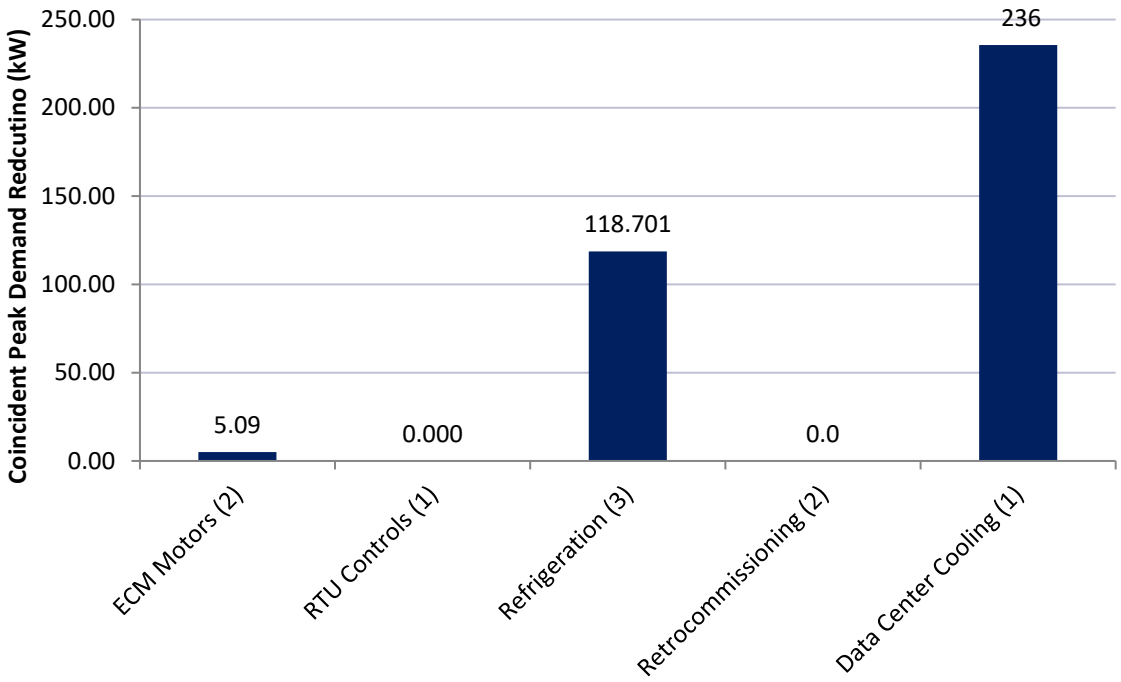

Figure 4-8: Commercial Custom – Coincident Peak Demand Reduction (kW) by Project Type

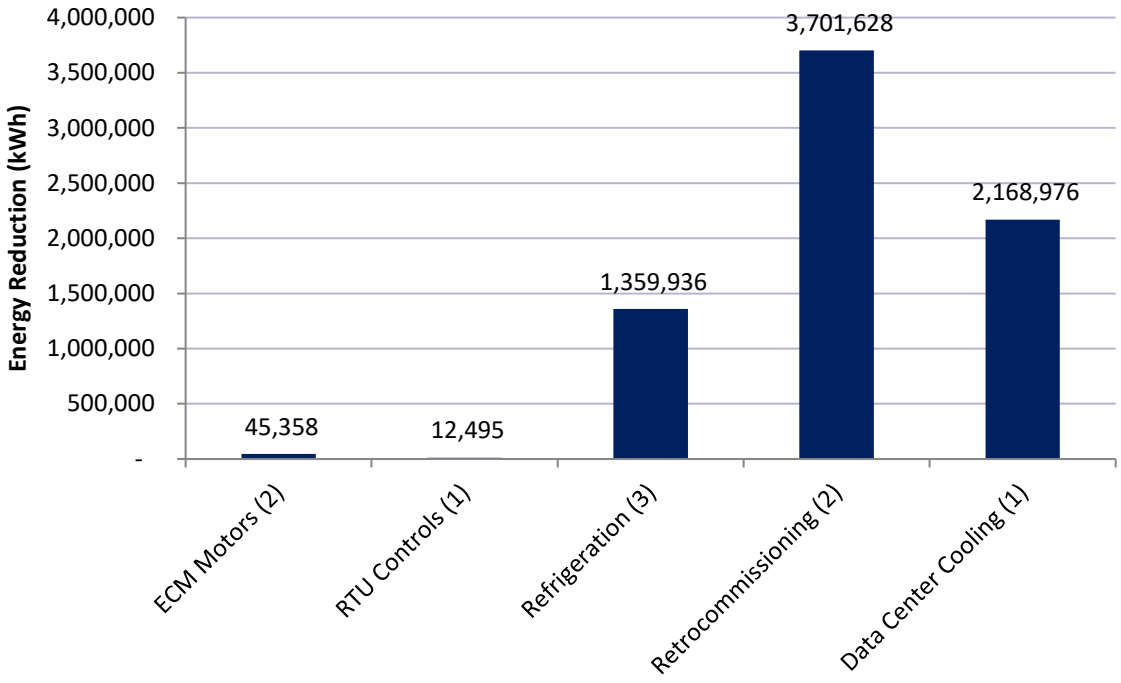

Figure 4-9: Commercial Custom – Energy Reduction (kWh) by Project Type

The following are program findings and recommendations CPS Energy may consider for this program in the future:

- Some of the projects evaluated under the custom program have recently been added to the *CPS Energy Guidebook* with deemed approaches to measure savings. In future program years, these measure types will be able to benefit from the streamlined savings determination as approved in the *CPS Energy Guidebook*. These measures include ECMs and Refrigeration.
- Continue to submit measurement and verification plans prior to project implementation in order to obtain pre-approval on custom projects.

4.5 COMMERCIAL NEW CONSTRUCTION PROGRAM

4.5.1 Overview

In FY 2016, CPS Energy paid incentives totaling $1,061,486 for four commercial new construction projects at the following rates:

- $0.08/kWh and $125/kW for savings 15-25% above code (Tier 1)
- $0.12/kWh and $150/kW for savings 25-35% above code (Tier 2)
- $0.20/kWh and $200/kW for savings more than 35% above code (Tier 3)

All four commercial new construction projects (100%) were for retail sites. During the course of FY 2017, the internal review process for this program, revised in FY 2013, was continued. Customers were required to submit whole building energy models in approved software and complete sets of design documents. Each project was reviewed by the EM&V consultant, with energy models first compared to design documents to confirm accurate modeling, and then compared to ASHRAE baselines to confirm calculations of savings relative to code.

4.5.2 Savings Calculation Method

Savings calculations were based on confirmed energy models. The models provide savings between the new building design and a corresponding reference design meeting minimum code requirements.

4.5.3 Results and Recommendations

The gross energy and demand savings calculated for the Commercial New Construction program are listed in Table 4-9.

Table 4-9: Commercial New Construction Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial New Construction	7,608,946	1,065	1,123	1,041

The following are findings and recommendations that CPS Energy may consider for future implementation of this program:

- Because of the relatively small number of projects, continue requiring submittal and EM&V review of simulation models and design documents for each project. Consider methods to streamline this review.

- Continue requiring customers to submit whole building energy models and complete sets of design documents for each project. Confirm (or add) the following submittals required for EM&V review (each project) prior to rebate disbursement:
    - Approved contractor product submittals for HVAC and lighting equipment, or product sheets from operations and maintenance (O&M) manual.
    - Simulation summary reports.
    - Hourly energy output files.
    - Demand and energy savings calculation file (spreadsheet).
    - Commissioning Report and HVAC TAB (test, adjust & balance) Report. Review of these reports will confirm initial building control settings are in accordance with design.
- We also recommend a visual site inspection be conducted post construction and before occupancy to confirm that as-built conditions match design documents.
- To have a better confidence in the persistence of the savings from new construction projects, we recommend a follow-up one year after occupancy. The follow-up can take a non-invasive approach by using meter data for the facility to measure against as-built energy models. The empirical data will help assess the reasonableness of modeled energy savings estimates, and the results may be useful in guiding new construction program design for future years. In order to implement this recommendation, it is necessary to ensure that whole building energy models are obtained and retained at the time of application submittal.

4.6 C&I SOLUTIONS

4.6.1 Overview

This program includes the installation of the following commercial energy-efficiency measures: lighting, lighting controls, and HVAC tune-up. In FY 2017, a total of 18 lighting and/or lighting controls projects were incentivized through the C&I Solutions program. In addition, 5 HVAC tune-ups were also incentivized during the FY2017 program year.

No comparison can be made to participation in previous years because FY 2017 represents the inception of this program.

The figures below present percentage breakdowns of kWh energy savings. For lighting projects, energy savings are presented by fixture type and building type for sampled lighting projects completed through this program. The values in these graphs are only representative of the kWh percentage breakdown for projects where a desk review was completed.

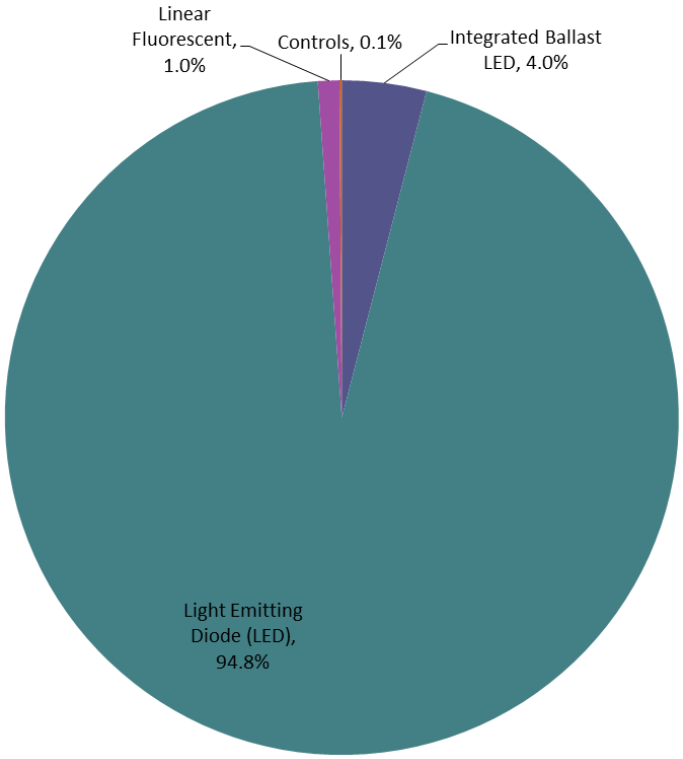

Figure 4-10: C&I Solutions – Percent of kWh Savings by Fixture Type for Sampled Projects

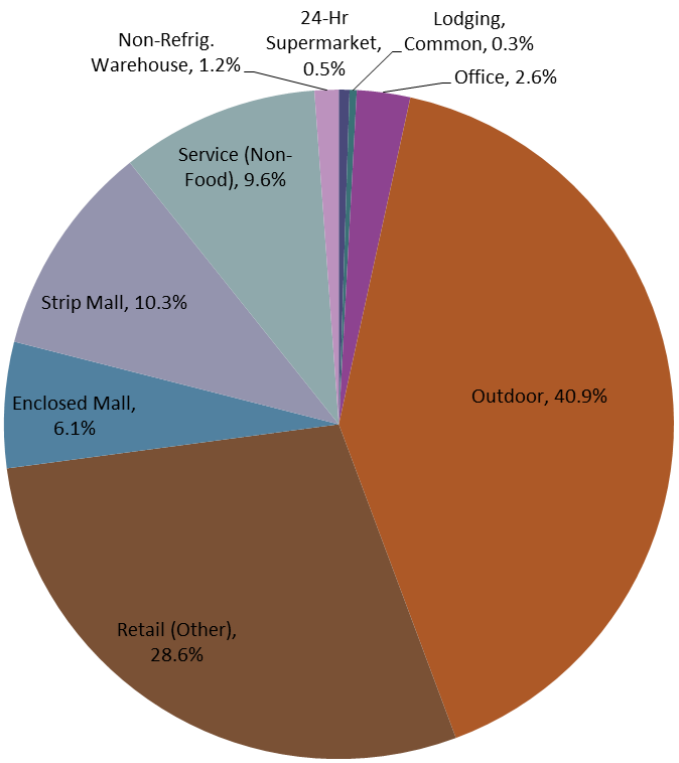

Figure 4-11: C&I Solutions - Percent of kWh Savings by Building Type for Lighting Sampled Projects

All HVAC tune-up projects for the C&I program were for Religious Worship building types and representing 100% the verified energy and demand savings for projects completed through his program.

4.6.2 Savings Calculation Method

A desk review was performed for a sample projects incentivized in this program. Frontier Associates selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were then applied to the full project population.

Lighting and Lighting Controls

Frontier randomly selected a sample of 31 lighting projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. The savings calculation is different for new construction and retrofit project. General savings algorithms are specified below. For retrofit projects, the savings are represented by the change in existing and installed wattage with the inclusion of applicable adjustment factors. For new construction projects, the savings are calculated based on the difference of the installed wattage and a per square foot lighting power allowance that is specified for various building types (referred to as the lighting power density, or LPD). Refer to the *CPS Energy Guidebook* for a detailed overview of the savings methodology used to evaluate this measure.

Retrofit:

$$Peak\ Demand\ Savings = (kW_{pre} - kW_{installed}) \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = (kW_{pre} - kW_{installed}) \times Hours \times HVAC_{energy}$$

New Construction:

$$Peak\ Demand\ Savings = \left(\frac{LPD \times Floor\ Area}{1{,}000} - kW_{installed}\right) \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = \left(\frac{LPD \times Floor\ Area}{1{,}000} - kW_{installed}\right) \times Hours \times HVAC_{energy}$$

First, claimed pre/post fixture counts and wattages were verified against project documentation. Hours of operation and demand factors were also verified against the reported building type.

For lighting installed in a conditioned space, Frontier awarded additional savings to account for HVAC/refrigeration interactive effects of the projects. A reduced lighting load reduces the internal heat gain to the building, which reduces the cooling load but increases the heating load. In order to estimate interactive effects for high-efficiency lighting installed in conditioned spaces, Frontier applied the following deemed interactive effects factors to the applicable projects:

Table 4-10: Commercial Lighting HVAC Interactive Effects Factors

Space Cooling Type	HVACdemand Factor	HVACenergy Factor
Air Conditioned	1.10	1.05
Medium Temperature Refrigeration (33 to 41°F)	1.25	1.25
Low Temperature Refrigeration (-10 to 10°F)	1.30	1.30
None (Unconditioned)	1.00	1.00

The non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand factors used to estimate demand savings for this measure were derived using an approach adapted from the method outlined in Section 2.3 of the CPS Energy Guidebook. First, lighting schedules were extracted from EnergyPlus energy simulation models developed for the commercial HVAC measures based on Department of Energy (DOE) commercial reference buildings.[22] Next, hourly percentages of lighting in operation were extracted from the lighting schedules. The resulting lighting factors were weighted using the probabilities assigned to each of the top 20 peak hours and 4CP hours. NCP factors match the maximum lighting factor from the lighting schedule for each building type.

[22] DOE Commercial Reference Buildings: http://energy.gov/eere/buildings/commercial-reference-buildings.

After the inclusion of HVAC interactive effects, it is possible that the CP or 4CP verified savings would exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project.

Existing lighting controls were used to reduce the deemed demand factors and operating hours used to calculate the baseline power and energy usage for existing lighting equipment. For installed lighting controls, savings were calculated by applying a deemed savings factor against the installed wattage.

$$Peak\ Demand\ Savings = kW_{controlled} \times Control\ Savings\ Factor \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = kW_{controlled} \times Control\ Savings\ Factor \times Hours \times HVAC_{energy}$$

The deemed control savings factors are presented in the following table:

Table 4-11: Lighting Controls – Savings Factors[23]

Control Type	Sub-Category	Savings Factor
None	n/a	0.00
Occupancy	n/a	0.24
Daylighting (Indoor)	Continuous dimming	0.28
	Multiple step dimming	
	ON/OFF	
Outdoor[24]	n/a	0.00
Personal Tuning	n/a	0.31
Institutional Tuning	n/a	0.36
Multiple/Combined Types	Various combinations	0.38

HVAC Tune-Up

Frontier selected all HVAC tune-up projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. General savings algorithms are specified below.

$$Energy\ (Cooling)\ [kWh_{Savings,C}] = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times \frac{EFLH_C}{1{,}000}$$

[23] Williams, Alison, Atkinson, Barbara, Garbesi, Karina, & Rubinstein, Francis, "A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings". Lawrence Berkeley National Laboratory. September 2011. Table 6, p. 14. Weighted average by number of "reviewed" and "non reviewed" papers.

[24] No control savings are allowed for outdoor controls because they are already required by code. ASHRAE 90.1-1989, Section 6.4.2.8 specifies that exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell, or a combination of timer and photocell. This is consistent with current specifications in ASHRAE 90.1-2010, Section 9.4.1.3, which specifies that lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours.

Demand savings were estimated by applying the annual energy savings against a building-type specific load shape. From the resulting data, non-coincident peak (NCP) demand savings were determined by identifying the maximum demand reduction during the entire year. Coincident peak (CP) demand savings were calculated according to the procedure outlined in Section 2.2. ERCOT 4CP Transmission cost savings were calculated using the procedure outlined in Section 2.4.2.

4.6.3 Results and Recommendations

Lighting and Lighting Controls

The desk review sample included projects from the CLEAResult C&I Solutions, Schools and Institutions, and Small Business Solutions programs. A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the entire sample. The weighted average realization rates were then applied to the entire project population (both sampled and un-sampled) for all three programs.

The weighted average realization rate for the lighting and lighting controls projects were 102.6% for NCP kW demand savings and 100.5% for kWh energy savings. The weighted average estimated useful life (EUL) applied to the verified savings was 14.8 years.

The data available in the CLEAResult lighting calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post fixture types, fixture counts, wattages, and control types. Additionally burn hours and demand factors are determined based on the identified building type. While the recommendations for commercial lighting measures in previous evaluations have had a heavy focus on data collection, Frontier has determined that data format is sufficient for this program. However, Frontier makes the following recommendations to enhance data reporting structure and help refine the precision of verified savings for future program years.

- For future program years, the savings calculations should match those specified in the *CPS Energy Guidebook* for the current program year. “Grandfathered” projects should no longer be using savings methodologies specified in previous evaluations.
- Upon request, CLEAResult should be prepared to submit unprotected versions of lighting workbooks for a subset of sampled projects in addition to the unprotected blank workbook that was submitted prior to the FY 2017 evaluation. This will reduce the amount of time required to perform a desk review on the sampled projects.
- As often as possible, CLEAResult should notify Frontier and CPS Energy of projects before installation so that Frontier and/or CPS Energy have the option to perform a pre-inspection for sampled projects.

HVAC Tune-Up

Savings calculations for the tune-up measure from the *CPS Energy Guidebook* were compared to CLEAResult M&V data for projects available. Realization rates were generated using the M&V data as the verified savings and the Guidebook calculations as the estimated savings. These realization rates

were then applied to the remaining stipulated projects based on the Guidebook estimated savings of each of the units that had a tune-up procedure.

The data available in the CLEAResult Tune-up calculator displayed all necessary inputs used by the evaluation team to validate program savings claims, including pre and post efficiencies, M&V data, capacity, and building type.

Frontier makes the following recommendations to enhance data reporting structure and help refine the precision of verified savings on HVAC Tune-up for future program years.

- Project data should only include information that is used to calculate total energy and demand savings. For example, if heating savings are not awarded for a particular system type, it is not required to display system information related to heating performance.
- Display what type of system received the tune-up procedure for each item. Manufacture and nominal tonnage are displayed but having AC or HP would be helpful in estimating savings appropriately.

CLEAResult was able to review the listed recommendation above and understand the opportunity for process optimization in data reporting for the HVAC Tune-up measure.

Table 4-12: C&I Solutions Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Non-Coincident kW Savings	Annual Coincident Peak kW Savings	TCOS 4CP kW Savings
Commercial Lighting	1,682,410	396.40	327.99	328.31
HVAC Tune-up	29,707	35.10	32.20	30.00
Total	**1,712,117**	**431.50**	**360.19**	**358.31**

4.7 SCHOOLS AND INSTITUTIONS

The Schools and Institutions program is a new program implemented by CLEAResult. No project data was submitted to Frontier for evaluation under the Schools and Institutions program in FY 2017.

4.8 SMALL BUSINESS SOLUTIONS

4.8.1 Overview

This program includes the installation of the following commercial energy-efficiency measures: lighting and lighting controls. In FY 2017, a total of 13 lighting and/or lighting controls projects were incentivized through the Small Business Solutions program.

No comparison can be made to participation in previous years because FY 2017 represents the inception of this program.

The figures below present project count and verified kWh energy savings breakdowns by building type for the sampled lighting projects completed through this program. The values in these graphs are only representative of the kWh percentage breakdown for projects where a desk review was completed.

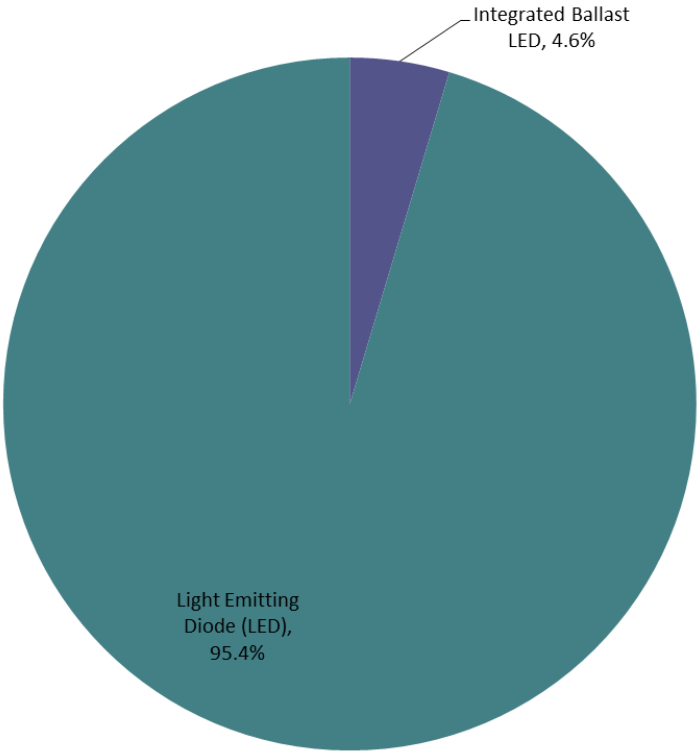

Figure 4-12: Small Business Solutions – Percent of kWh Savings by Fixture Type for Sampled Projects

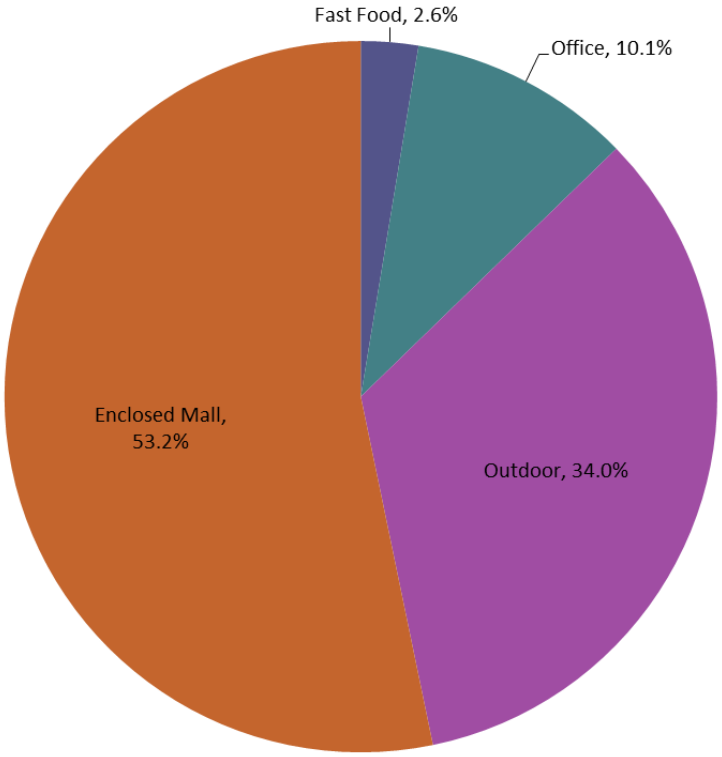

Figure 4-13: Small Business Solutions – Percent of kWh Savings by Building Type for Sampled Projects

4.8.2 Savings Calculation Method

A desk review was performed for a sample projects incentivized in this program. Frontier selected a sample size to achieve a 90/10% confidence and precision interval. The results of the savings analysis for the sample were then applied to the full project population.

Lighting and Lighting Controls

Frontier randomly selected a sample of 31 lighting projects for desk review. Savings for all sampled projects were validated using the savings methodologies outlined in the *CPS Energy Guidebook*. The savings calculation is different for new construction and retrofit project. General savings algorithms are specified below. For retrofit projects, the savings are represented by the change in existing and installed wattage with the inclusion of applicable adjustment factors. For new construction projects, the savings are calculated based on the difference of the installed wattage and a per square foot lighting power allowance that is specified for various building types (referred to as the lighting power density, or LPD). Refer to the *CPS Energy Guidebook* for a detailed overview of the savings methodology used to evaluate this measure.

Retrofit:

$$Peak\ Demand\ Savings = (kW_{pre} - kW_{installed}) \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = (kW_{pre} - kW_{installed}) \times Hours \times HVAC_{energy}$$

New Construction:

$$Peak\ Demand\ Savings = \left(\frac{LPD \times Floor\ Area}{1{,}000} - kW_{installed}\right) \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = \left(\frac{LPD \times Floor\ Area}{1{,}000} - kW_{installed}\right) \times Hours \times HVAC_{energy}$$

First, claimed pre/post fixture counts and wattages were verified against project documentation. Hours of operation and demand factors were also verified against the reported building type.

For lighting installed in a conditioned space, Frontier awarded additional savings to account for HVAC/refrigeration interactive effects of the projects. A reduced lighting load reduces the internal heat gain to the building, which reduces the cooling load but increases the heating load. In order to estimate interactive effects for high-efficiency lighting installed in conditioned spaces, Frontier applied the following deemed interactive effects factors to the applicable projects:

Table 4-13: Commercial Lighting HVAC Interactive Effects Factors

Space Cooling Type	HVACdemand Factor	HVACenergy Factor
Air Conditioned	1.10	1.05
Medium Temperature Refrigeration (33 to 41°F)	1.25	1.25
Low Temperature Refrigeration (-10 to 10°F)	1.30	1.30
None (Unconditioned)	1.00	1.00

The non-coincident peak (NCP), coincident peak (CP), and four coincidental peaks (4CP) demand factors used to estimate demand savings for this measure were derived using an approach adapted from the method outlined in Section 2.3 of the CPS Energy Guidebook. First, lighting schedules were extracted from BEopt energy simulation models developed for the commercial HVAC measures based on Department of Energy (DOE) commercial reference buildings.[25] Next, hourly percentages of lighting in operation were extracted from the lighting schedules. The resulting lighting factors were weighted using the probabilities assigned to each of the top 20 peak hours and 4CP hours. NCP factors match the maximum lighting factor from the lighting schedule for each building type.

[25] DOE Commercial Reference Buildings: http://energy.gov/eere/buildings/commercial-reference-buildings.

After the inclusion of HVAC interactive effects, it is possible that the CP or 4CP verified savings would exceed the verified NCP savings despite the higher NCP demand factor. In these instances, the CP or 4CP (higher of the two) was substituted as the verified NCP demand savings for that project.

Existing lighting controls were used to reduce the deemed demand factors and operating hours used to calculate the baseline power and energy usage for existing lighting equipment. For installed lighting controls, savings were calculated by applying a deemed savings factor against the installed wattage.

$$Peak\ Demand\ Savings = kW_{controlled} \times Control\ Savings\ Factor \times Demand\ Factor \times HVAC_{demand}$$

$$Energy\ Savings = kW_{controlled} \times Control\ Savings\ Factor \times Hours \times HVAC_{energy}$$

The deemed control savings factors are presented in the following table:

Table 4-14: Lighting Controls – Savings Factors[26]

Control Type	Sub-Category	Savings Factor
None	n/a	0.00
Occupancy	n/a	0.24
Daylighting (Indoor)	Continuous dimming	0.28
	Multiple step dimming	
	ON/OFF	
Outdoor[27]	n/a	0.00
Personal Tuning	n/a	0.31
Institutional Tuning	n/a	0.36
Multiple/Combined Types	Various combinations	0.38

4.8.3 Results and Recommendations

Lighting and Lighting Controls

The desk review sample included projects from the CLEAResult C&I Solutions, Schools and Institutions, and Small Business Solutions programs. A weighted average realization rate (weighted by claimed NCP kW and kWh savings) was calculated for the entire sample. The weighted average realization rates were then applied to the entire project population (both sampled and un-sampled) for all three programs.

[26] Williams, Alison, Atkinson, Barbara, Garbesi, Karina, & Rubinstein, Francis, "A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings". Lawrence Berkeley National Laboratory. September 2011. Table 6, p. 14. Weighted average by number of "reviewed" and "non reviewed" papers.

[27] No control savings are allowed for outdoor controls because they are already required by code. ASHRAE 90.1-1989, Section 6.4.2.8 specifies that exterior lighting not intended for 24-hour continuous use shall be automatically switched by timer, photocell, or a combination of timer and photocell. This is consistent with current specifications in ASHRAE 90.1-2010, Section 9.4.1.3, which specifies that lighting for all exterior applications shall have automatic controls capable of turning off exterior lighting when sufficient daylight is available or when the lighting is not required during nighttime hours.

The weighted average realization rate for the lighting and lighting controls projects were 102.6% for NCP kW demand savings and 100.5% for kWh energy savings. The weighted average estimated useful life (EUL) applied to the verified savings was 14.8 years.

The data available in the CLEAResult lighting calculator aligns closely with the inputs used by the evaluation team to validate program savings claims, including pre and post fixture types, fixture counts, wattages, and control types. Additionally burn hours and demand factors are determined based on the identified building type. While the recommendations for commercial lighting measures in previous evaluations have had a heavy focus on data collection, Frontier has determined that data format is sufficient for this program. However, Frontier makes the following recommendations to enhance data reporting structure and help refine the precision of verified savings for future program years.

- For future program years, the savings calculations should match those specified in the *CPS Energy Guidebook* for the current program year. "Grandfathered" projects should no longer be using savings methodologies specified in previous evaluations.
- Upon request, CLEAResult should be prepared to submit unprotected versions of lighting workbooks for a subset of sampled projects in addition to the unprotected blank workbook that was submitted prior to the FY 2017 evaluation. This will reduce the amount of time required to perform a desk review on the sampled projects.
- As often as possible, CLEAResult should notify Frontier and CPS Energy of projects before installation so that Frontier and/or CPS Energy have the option to perform a pre-inspection for sampled projects.

Table 4-15: C&I Solutions Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Non-Coincident kW Savings	Annual Coincident Peak kW Savings	TCOS 4CP kW Savings
Commercial Lighting	362,669	92.00	14.21	14.22

4.9 WHOLE BUILDING OPTIMIZATION

The Whole Building Optimization program is a new program implemented by CLEAResult. No project data was submitted to Frontier for evaluation under the Whole Building Optimization program.

5. DEMAND RESPONSE PROGRAMS

5.1 SUMMARY OF DEMAND RESPONSE IMPACTS

CPS Energy offered the following demand response programs in FY 2017:

- Commercial Demand Response - Commercial & Industrial customers are incentivized to reduce energy use during times of peak summer demand. Demand Response customers take steps to lower their facilities' energy demand for a 1 to 3 hour curtailment period. Their performance is evaluated and incentives are tied to their ability to meet a performance curtailment. CPS Energy offers three different demand response participation options (Options 1-3), as well as an Automated Demand Response (ADR) option. These options vary by performance period, events available, total hours available and advance notice.

- Residential Demand Response programs – offer residential customers the opportunity to contribute to load reduction during times of peak summer demand.

    - Smart Thermostat – offers free installation of a free Honeywell programmable thermostat in participating customers' homes when they enroll, and uses the thermostat to cycle off the compressor of participating air conditioners during periods of peak demand throughout the summer.

    - Home Manager - an innovative home energy management system, designed by Consert, Inc. Load control devices are placed on a participant's air conditioner, water heater and pool pump where applicable. A gateway, which is the brain of the Home Manager system, uses a wireless network to relay information between a CPS Energy data center and the system devices installed in the home.

    - Bring Your Own Thermostat (BYOT) - CPS Energy has teamed up with Nest, Honeywell, and Energy Hub to offer customers with smart thermostats to participate in CPS Energy's load management events.

The contribution of each demand response program to energy, peak demand and non-coincident peak savings are shown in Figure 5-3, Figure 5-1, and Figure 5-2. In these figures and in Table 1-2 and Table 7-1, we report estimated savings from all active participants to most accurately represent the programs' actual capability at the end of FY 2017. These savings are adjusted to account for net-to-gross ratios and distribution line losses.[28]

[28] Net-to-gross (NTG) ratios are estimated at the level of individual programs, and account for the net effects of free ridership and spillover. Free riders are defined as customers who would have delivered energy or demand savings without any program incentives but who received a financial incentive or rebate anyway. Spillover effects derive from customers who delivered energy or demand savings because of the program, but did not participate in the program or receive a financial incentive or rebate. Distribution line losses account for the fact that utilities must generate or import a greater amount of energy or demand than is required at the customer or end-user level because some energy is lost on the distribution system.

For benefit-cost calculations, our approach focuses on the incremental impacts of only new participants added in FY 2017, consistent with the approach used in all energy efficiency program benefit-cost calculations.

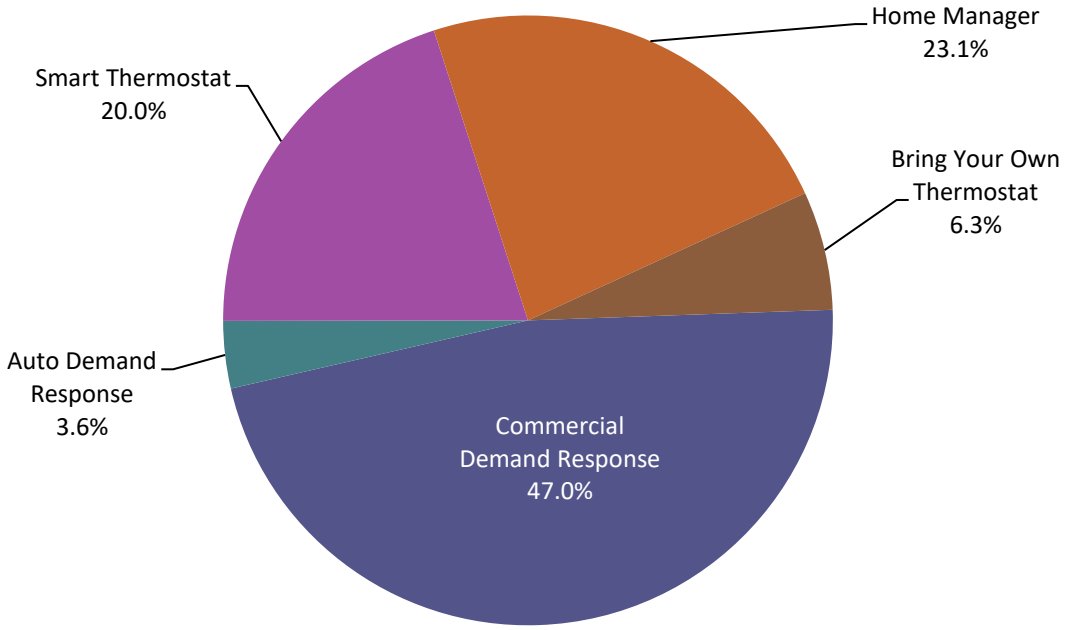

Figure 5-1: Summary of Demand Response Impacts – Peak Demand (kW) by Program

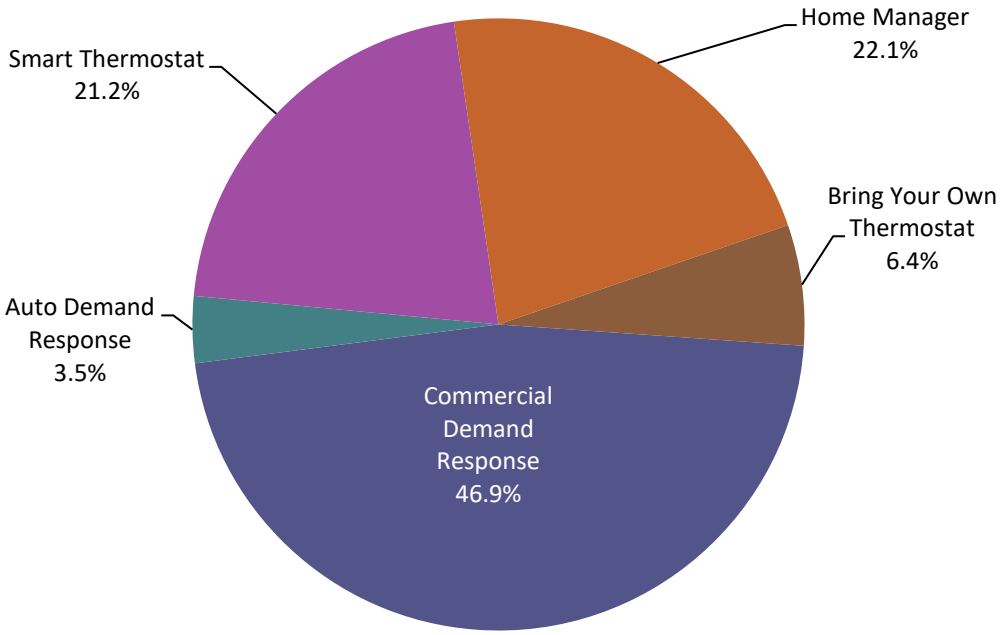

Figure 5-2: Summary of Demand Response Impacts – Non-Coincident Peak Demand (kW) by Program

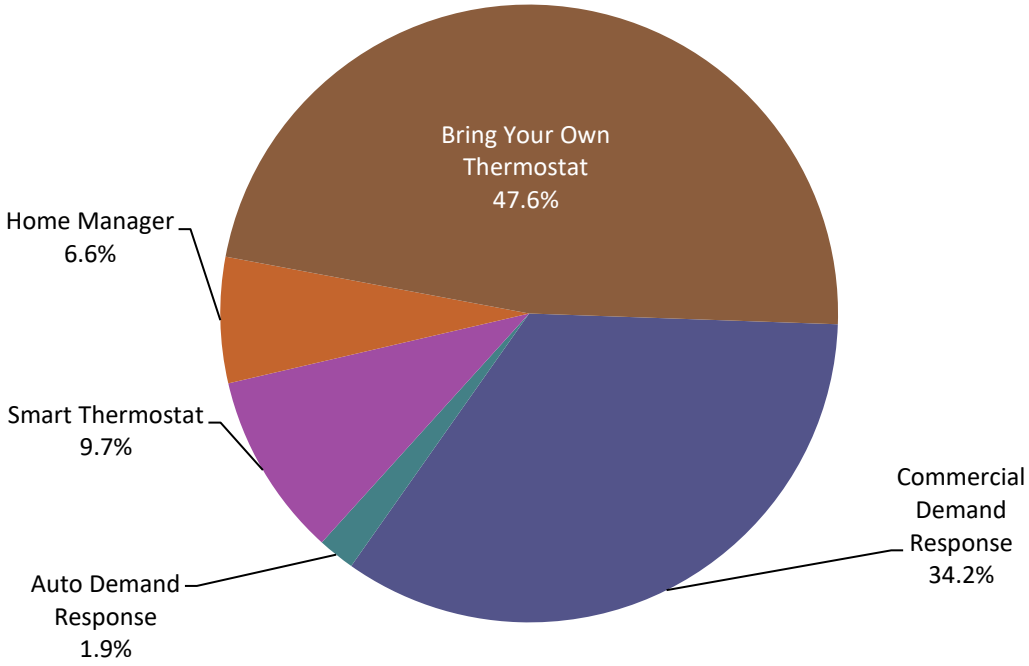

Figure 5-3: Summary of Demand Response Impacts – Energy (kWh) by Program

5.2 COMMERCIAL AND AUTO DEMAND RESPONSE PROGRAMS

5.2.1 Overview

CPS Energy's Commercial Demand Response (DR) programs are voluntary load curtailment programs for its commercial and industrial customers. The programs are designed to reduce CPS Energy's peak load growth by incentivizing customers to shed electric loads on peak summer days. The Commercial Demand Response programs run from June 1 through September 30. Participating customers commit to be available between 1 p.m. and 7 p.m.; typically, events occur on weekdays till 5:30 p.m.

In FY 2017, the Commercial DR programs consisted of:

- Commercial Demand Response (Options 1, 2, and 3)
- Automated Demand Response (ADR)

CPS Energy uses these programs differently because they have different purposes, capabilities, and contractual stipulations. Table 5-1 summarizes these differences.

Table 5-1: Commercial DR Program Characteristics

Measure	Performance Period	Time Period	Event Days	Max Events	Total Hours Avail.	Advance Notice (hrs)
Option 1	Jul 1 - Aug 31	1300 - 1900	Weekdays	18	55	2
Option 2	Jun 1 – Sep 30	1300 - 1900	Weekdays	25	75	2
Option 3	Jun 1 – Sep 30	1300 - 1900	Weekdays	6	25	1
ADR *	Jun 1 – Sep 30	24/7	All Days	N/A	50	0
* There is also a non-summer ADR program offering that runs for the rest of the year, but its impacts are not evaluated herein.						

As can be seen from the table above, programs vary by performance period, events available, total hours available and advance notice:

- Option 1 is not available in June and September; other programs last the whole summer period.
- ADR is the most responsive, with load being curtailed immediately after calling; other programs have 1 to 2 hours of advance notice.

5.2.2 Participation Trends

As can be seen in Figure 5-4 there has been an upward trend from FY 2015 to FY 2017 in the number of sponsors and number of sites. In FY 2017, there was an increase in the number of total sponsors and participating sites, while the total contracted kW dropped compared with that in FY 2016.

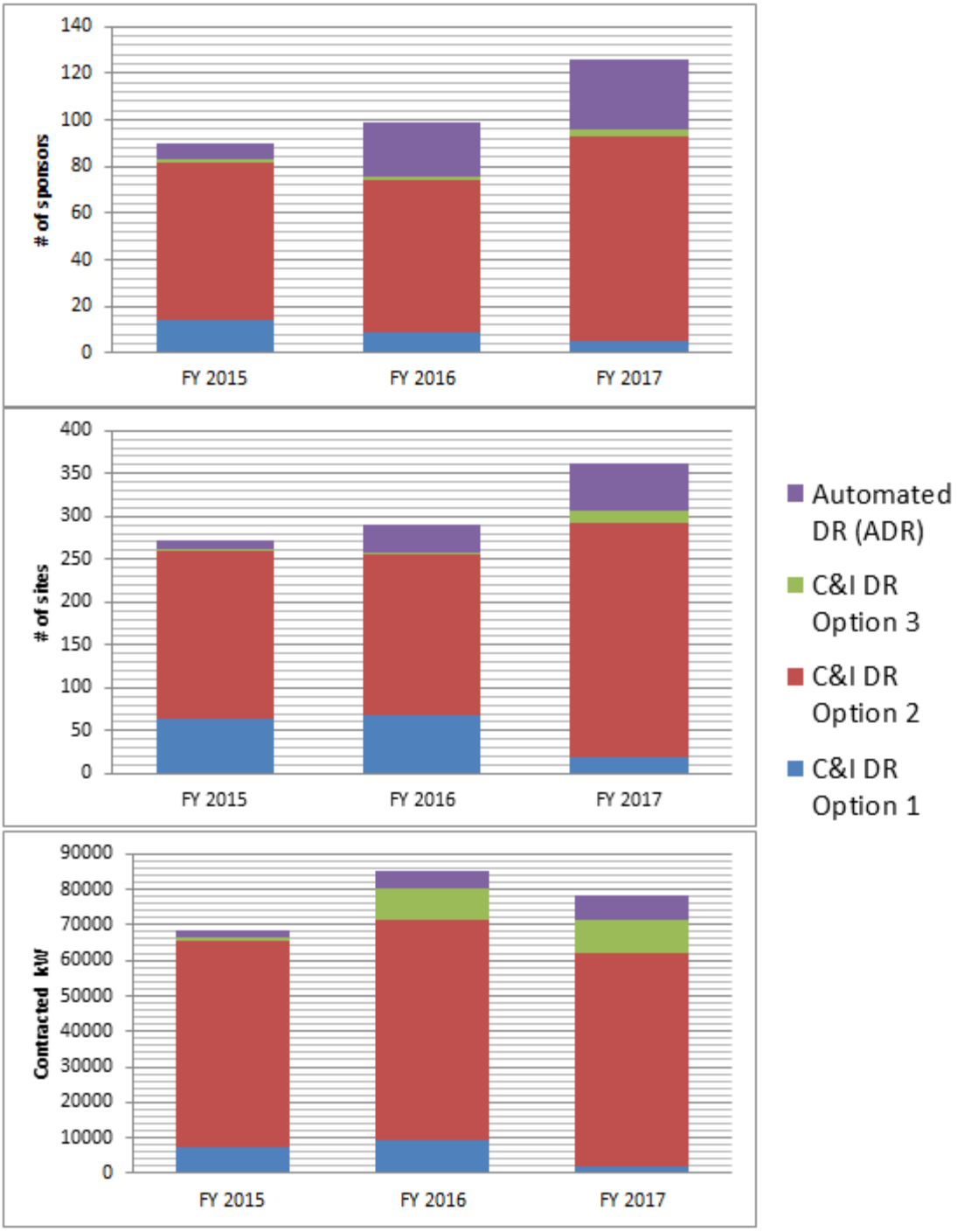

Figure 5-4: Commercial DR - Participation and Contracted kW, FY 2015 –FY 2016

Specifically, there was a significant drop in customer participation under option 1. The contracted kW fell from 9370 kW (FY 2016) to 1735 kW. However, there were more customers joining in ADR programs this year, with the number of sites increased from 34 to 54, contracted kW increased from 4,940 kW to 6,716 kW compared with that in FY 2016.

CPS Energy deployed its Commercial DR programs on 21 days in FY 2017. As can be seen in Table 5-2, Option 2 and the ADR programs were called most frequently, while Option 3 was only called 6 times due to a limit on the maximum number of events that can be called under this program.

Table 5-2: Commercial DR Events and Average Duration by Program Offering

C&I DR Program/ Option	June				July				August								September					Total Events #
	15	16	17	30	13	14	21	22	3	4	5	8	9	10	11	12	1	6	7	8	19	
Option 1					x	x	x	x	x	x		x	x	x	x	x						11
Option 2	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	19
Option 3						x		x						x			x		x	x		6
ADR			x		x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	18
Total	**1**	**1**	**1**	**1**	**3**	**4**	**3**	**4**	**3**	**3**	**1**	**3**	**2**	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**2**	**21**

There was an increase on the total number of events called in FY 2017 compared with that in FY 2016, as can be seen in Table 5-3 below:

Table 5-3: Commercial DR total # of Events called: FY 2017 vs FY 2016

C&I DR Program/ Option	FY 2017	FY 2016
Option 1	11	10
Option 2	19	13
Option 3	6	6
ADR	18	13
EDR	NA	1
Total	**21**	**17**

Figure 5-5 shows the average event duration between FY 2017 and FY 2016:

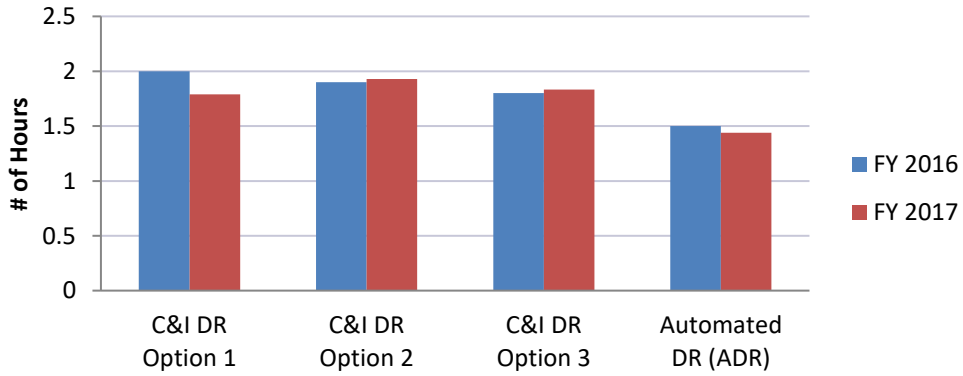

Figure 5-5: Commercial DR Average Event Duration, FY 2016 – FY 2017

5.2.3 Savings Calculation Methods

CPS Energy generally estimates delivered demand savings according to a High 3 of 10 baseline estimation method. In certain cases in which the High 3 of 10 baseline is not deemed to provide a reasonable baseline for a given participant for a given event, other methods such as using a single proxy day (like-day) or applying further adjustments by evaluators may be used.

To verify CPS Energy's estimated savings, Frontier has employed a rigid application of CPS Energy's High 3 of 10 baseline analysis as the primary estimating methodology and used panel data regression for benchmarking. These analyses produced results that are similar to CPS Energy's estimated savings.

5.2.3.1 Energy Savings (kWh)

Energy savings achieved from the Commercial DR programs are estimated by multiplying the demand savings estimated for each participant for each event by that event's duration and summing these energy reductions across all events for all the programs. The calculation assumes there is no load shifting (e.g. rescheduling of industrial processes) or pre-cooling or snapback associated with temperature-dependent loads.

5.2.3.1 Coincident Peak (CP) Demand Savings (kW)

To estimate coincident peak demand kW savings, Frontier estimated per event demand savings using rigid top 3-of-10 baseline analysis for each customer. For each option/program, an average kW savings of all events in summer 2016 was then calculated. This is the number used to report achieved CP savings.

5.2.3.2 Non-Coincident Peak (NCP) Demand Savings (kW)

Non-coincident peak demand savings for the Commercial DR programs represent the maximum event demand savings among all events for each option/program. The delivered NCP savings reported for each program (or program option) may have occurred on different event dates. End of year and incremental estimates of NCP savings were estimated as the maximum event demand savings from those customers comprising the end of year or incremental enrollees. For the Commercial DR program as a whole, Frontier sums the maximum event demand savings from each program option.

5.2.3.3 ERCOT 4CP Demand Savings (kW)

ERCOT 4CP demand savings obtained from the Commercial DR programs are directly estimated by evaluating the load reductions delivered when each month's 4CP event occurred.

5.2.4 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated program impacts during summer 2016 DR events.

2) End of year (EOY) program capability based on program enrollment at the end of FY 2017; this information is useful for planning purposes.

3) End of year (EOY) program capability based on incremental enrollment during FY 2017; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

For Options 1-3, there is no distinction between total EOY participation (no. 2 above) and incremental enrollment (no. 3 above): all participants are treated as new participants each program year. As such, the analysis of incremental impacts of these programs is no different than the analysis of total impacts.

5.2.4.1 Estimated Impacts During Summer 2016 DR Events

During summer 2016, C&I demand response events were called on 21 days. The aggregated kW savings estimate for these days are shown in Figure 5-6 below.

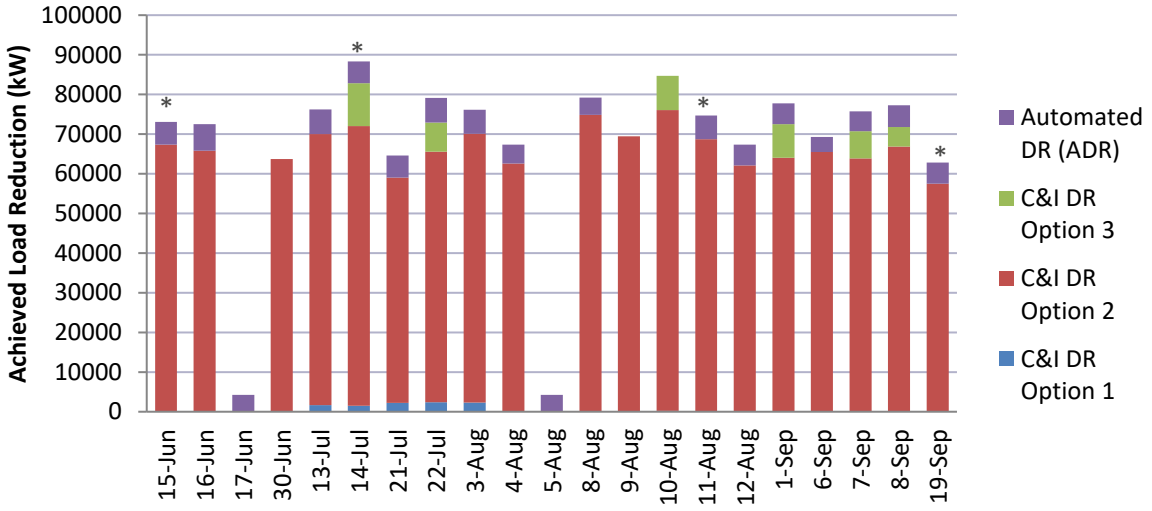

Figure 5-6: Commercial DR - Delivered Demand Savings, Summer 2016

Note: Events coinciding with ERCOT 4CP intervals are designated with a *.

Maximum total demand reductions were achieved on July 14th, which was also a 4CP day. The total C&I programs demand reduction was 88.3 MW on that day. Given the differences in how the individual Commercial DR programs are used, Frontier estimates the demand savings delivered by each program individually; total demand savings are presented as the sum of the demand savings delivered by each of the respective programs. The demand reduction and the number of customers participating for each option/program were shown in Figure 5-7 to Figure 5-10 below.

As can be seen from Figure 5-7, for option 1, there was a sharp drop after August 3rd event due to the fact that one major sponsor chose not to participate in the latter events.

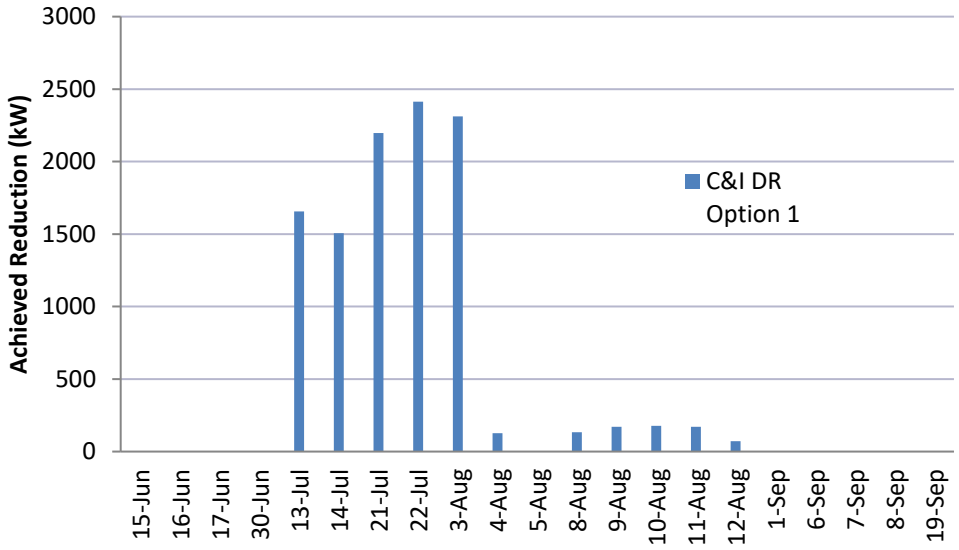

Figure 5-7: Commercial DR Option 1 Demand Savings by Event

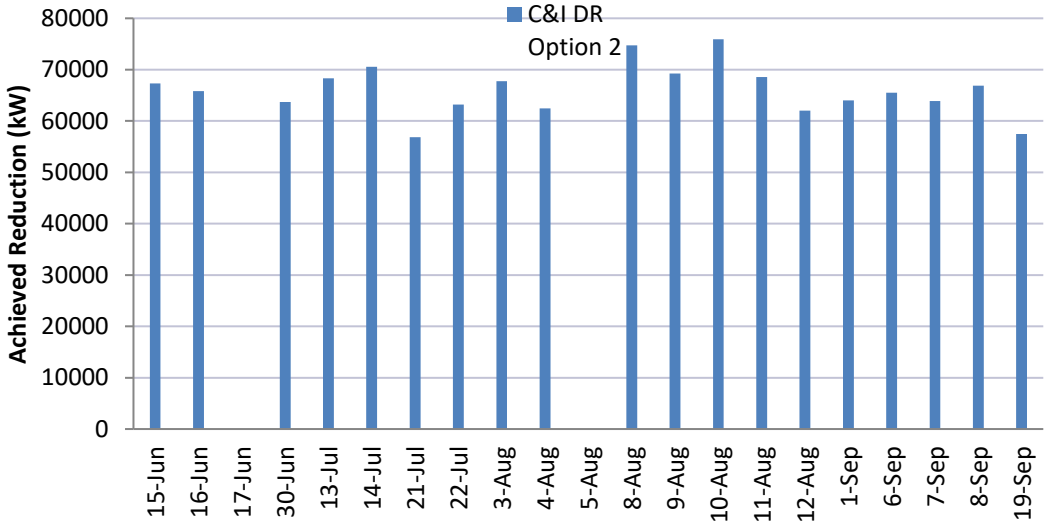

Figure 5-8: Commercial DR Option 2 Demand Savings by Event

The load reduction for option 2 remained relatively stable across all summer, with an average load reduction of about 66 MW across all 19 events.

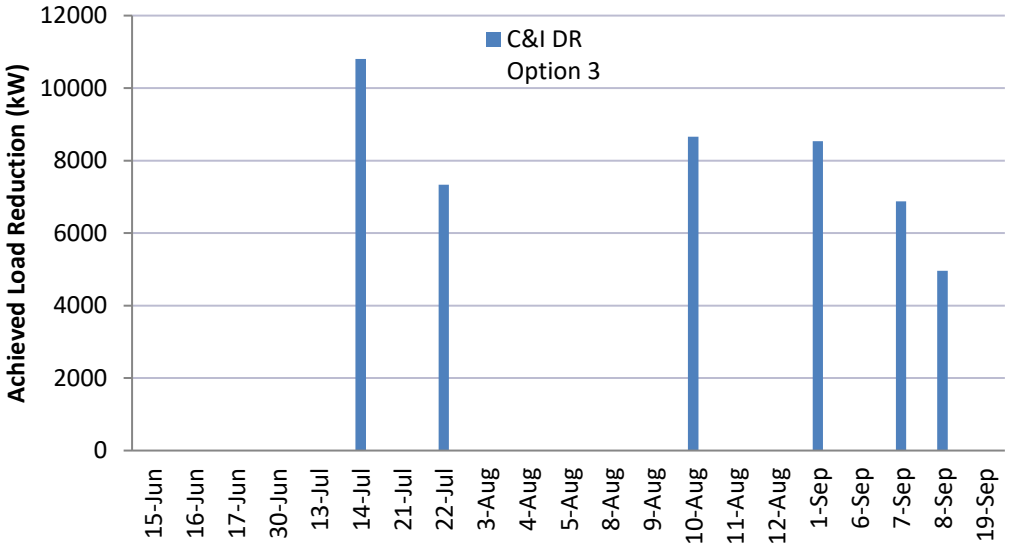

Figure 5-9: Commercial DR Option 3 Demand Savings by Event

Of the 6 events called in option 3, average load reduction achieved in summer 2016 was 7.86 MW.

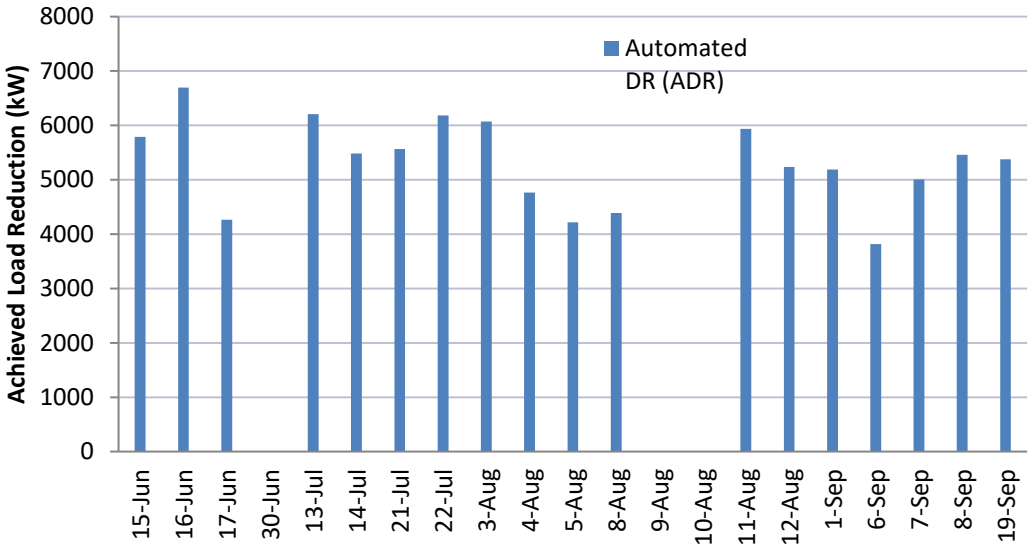

Figure 5-10: Commercial DR Automated DR Demand Savings by Event

Average demand savings delivered by participants in the Automated DR program was 5.68 MW.

A comparison of the estimated impacts between summer 2016 and summer 2015 is shown below:

Table 5-4: Commercial DR total # of Events called: FY 2017 vs FY 2016

C&I DR Program/ Option	FY 2017 Average Savings (kW)	FY 2016 Average Savings (kW)
Option 1	994	11,441
Option 2	66,010	67,317
Option 3	7,860	6,609
ADR	5,684	3,707
EDR	NA	17,903
Total	**80,548**	**106,977**

The savings decrease is mainly due to removal of EDR and a significant drop in Option 1.

FY 2017 Delivered Savings

Table 5-5 presents the different estimates of savings delivered by the Commercial DR programs for FY 2017.

Table 5-5: Commercial DR Gross Energy and Demand Savings – FY 2017 Delivered

Measure	Energy Savings (kWh)	Average Demand Savings (kW)	Coinc. Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Option 1	19,967	994	994	2,413	420
Option 2	2,306,811	66,010	66,010	75,910	65,974
Option 3	84,683	7,860	7,860	10,807	2,702
Automated DR	136,959	5,684	5,684	6,696	5,645
Total	**2,548,420**	**80,548**	**80,548**	**95,826**	**74,740**

5.2.4.1 End of Year Program Capability

Unlike residential DR programs which customers constantly sign up year round, most C&I DR programs are short and contract-based, lasting only 1-2 years, except for the ADR program. So for energy savings (kWh), coincident peak savings (kW) and non-coincident peak savings (kW), Frontier uses the savings achieved in summer 2016 as an end of year result. As for ERCOT 4CP demand savings, since 4CP chasing has a certain success rate, Frontier considers it reasonable to use the average success rate of past 3 fiscal years to estimate end of year program capability.

Table 5-6: Commercial DR – ERCOT 4CP Demand Savings – End of Year

Measure	FY 2015 Success Rate	FY 2016 Success Rate	FY 2017 Success Rate	Average Success Rate	Average Savings when Deployed, FY 2017 4CP Events	ERCOT 4CP Demand Savings (kW)
Option 1	25%	50%	50%	42%	420	350
Option 2	75%	75%	100%	83%	65,974	54,978
Option 3	50%	75%	25%	50%	2,702	5,404
Automated DR	75%	100%	100%	92%	5,645	5,174
Total						**65,906**

Option 1 participants are not available in June or September, meaning at least two 4CP events will always be missed with that program option. Option 3 participants are available for a maximum of six events, limiting CPS Energy's ability to use these program options for 4CP avoidance. Option 2 and ADR hit 4CP intervals 100% last summer 2016.

The end of year program capability is summarized as follows:

Table 5-7: Commercial DR Gross Energy and Demand Savings – End of Year Capability

Measure	Energy Savings (kWh)	Coinc. Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Option 1	19,967	994	2,413	350
Option 2	2,306,811	66,010	75,910	54,978
Option 3	84,683	7,860	10,807	5,404
Automated DR	136,959	5,684	6,696	5,174
Total	**2,548,420**	**80,548**	**95,826**	**65,906**

5.2.4.2 Incremental Impacts

For Options 1-3, there is no distinction between total participation and incremental participation: all participants are treated as new each program year. As such, the analysis of incremental impacts of these programs is no different from the analysis of total impacts.

The ADR program is a vendor-implemented program involving the installation of hardware. Moreover, customers sign longer-term contracts. Frontier has assigned the ADR program a 10-year measure life. For this program, incremental impacts differ from the total impacts. In FY 2017 the program added 21 new sites. Table 5-8 presents estimated incremental savings for the new additions to the ADR program

in FY 2017. The same approaches used for projecting the total capabilities of the Commercial DR program (above) have been applied to estimating the incremental capabilities of the ADR program. The same 92% success rate is projected for ERCOT 4CP avoidance as was used for all ADR participants.

Table 5-8: ADR Gross Energy and Demand Savings – Incremental Impacts

Measure	Energy Savings (kWh)	Coinc. Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Automated DR	29,248	1,482	1,919	1,242

5.2.5 Recommendations

Frontier makes the following recommendations for the Commercial DR programs.

- Evaluation methodology. Participating customers representing different industries have different load profiles, and there may be no single method for estimating savings that is most appropriate to all customers. In the past, CPS Energy has applied reasonable adjustments to calculate savings for different customers. Applying different methodologies on each occasion has its merits such as flexibility, however, this process tends to be time-consuming and may be somewhat arbitrary in the long run. Frontier recommends adopting a uniform procedure to select the most appropriate methodology for each customer based on different industries and weather situations. CPS Energy is currently in the process of implementing an automated system, AutoGrid DROMS, that should address this issue.

5.3 SMART THERMOSTAT PROGRAM

5.3.1 Overview

The Smart Thermostat direct load control program has been available to residential sector participants in single-family homes since 2003. It was expanded to include multifamily and small commercial customers in 2010. Through the program, CPS Energy installs a programmable, controllable thermostat (PCT) at participants' home or place of business at no cost to the customer. In return, CPS Energy is permitted to remotely control their central air conditioning systems during demand response events. Once an event is called, CPS Energy can cycle the air conditioner compressor on and off for short periods of time on event days. Cycling events occur during the summer months of May through September, between the hours of 3 p.m. and 7 p.m. on weekdays.

Single-family, multifamily and small commercial customers participate at either a 33% cycling rate (during which units are cycled off for 10 minutes during each half hour) or a 50% cycling rate (during which units are cycled off for 15 minutes during each half hour). Customers can choose either a pager-style thermostat or a WiFi-enabled thermostat. Pager thermostats are available on either 33% or 50% cycling rate, while WiFi Thermostats are only available for a 50% cycling rate.

Beginning in FY 2016, CPS Energy enabled customers who purchase and install their own qualifying thermostat to participate in a more broadly defined Bring Your Own Thermostat (BYOT) program. Some thermostats purchased and installed under BYOT participate and respond to DR events in a manner equivalent to those installed under the Smart Thermostat program, but are reported separately.

5.3.2 Participation Trends

Figure 5-11 below shows overall participation in the Smart Thermostat program at the beginning and end of FY 2017 and at the time of DR events during June through September 2016[29]. Overall participation increased by 5.2% in FY 2017.

[29] By the end of FY 2017, 1057 Honeywell thermostats participated in the CPS Energy BYOT program instead of the Smart Thermostat program. Estimated number of BYOT thermostats were removed from the Smart Thermostat program count.

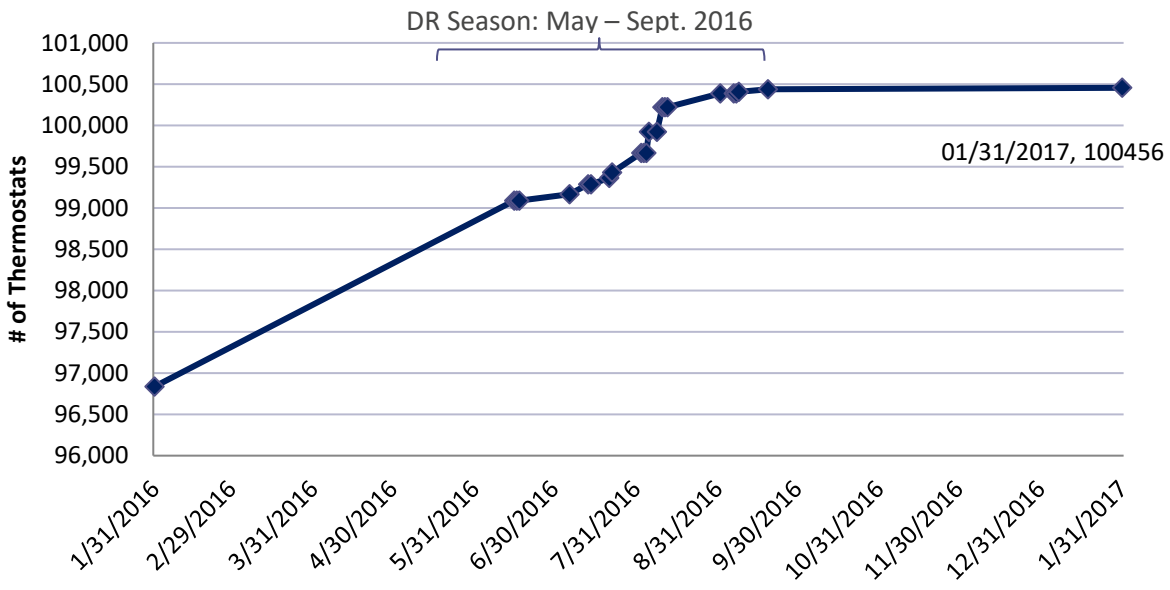

Figure 5-11: Smart Thermostat – Participation Trend (FY 2017) – Total Thermostats Count

Figure 5-12 shows participation trends by customer segment over the past four years. There has been a consecutive increase in participation for the Residential – 50% cycling, Multi-family and Commercial segments of the program. Participation in Residential – 33% cycling dropped from 42,940 to 38,661 over the past 4 years due to the fact that CPS Energy has been gradually shifting customers to the 50% cycling group.

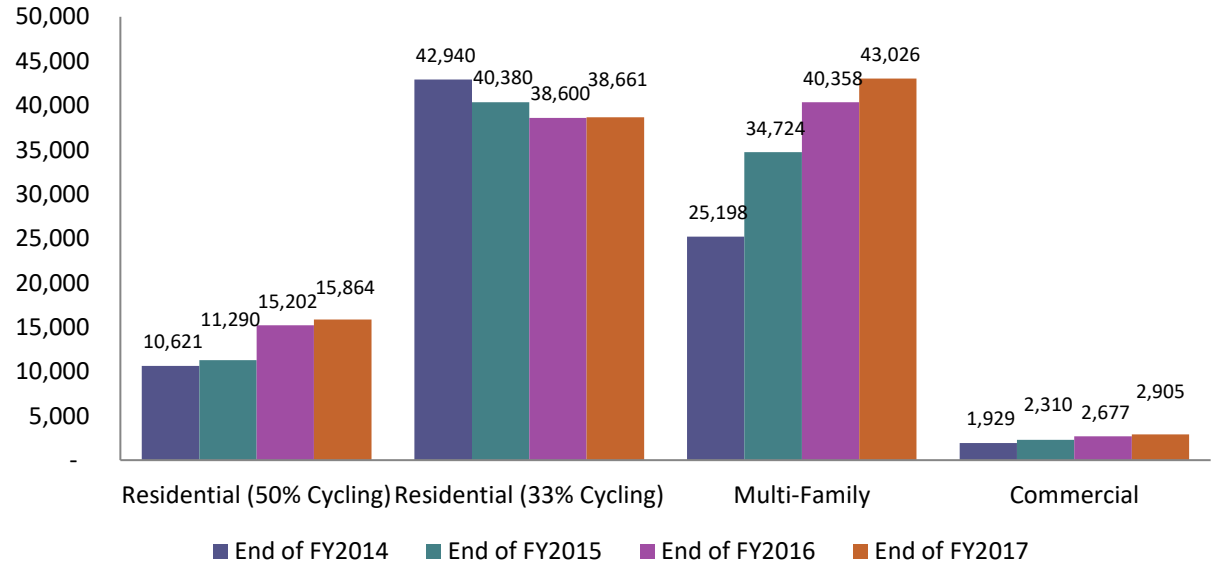

Figure 5-12: Smart Thermostat – Participation Trends (FY 2014-FY 2017) – By Segment

The following figure shows the participation share by segment from FY 2014 to FY 2017. Residential (33% Cycling) is the only segment that has a declining share for the past 4 years, since customers gradually shifted to the 50% cycling group. The Residential (50% Cycling) segment share increased from 13% to 16%, due to rapid growth in Wifi customers. The Multi-Family share has also increased from 31% to 43%.

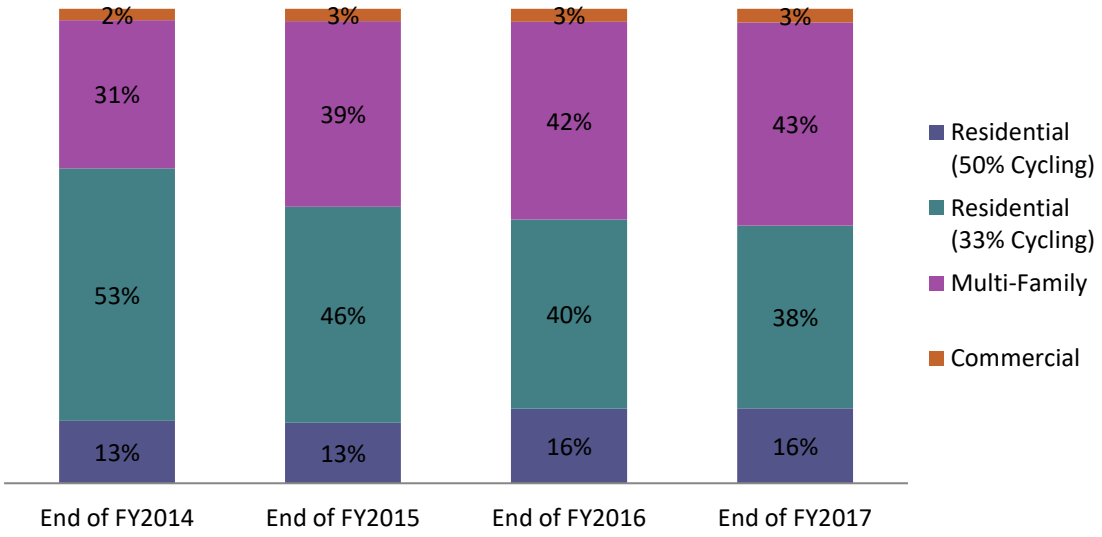

Figure 5-13: Smart Thermostat – Participation Share (FY 2014-FY 2017) – By Segment

Wifi customers comprised most of the new customer growth in FY 2017. The following figure shows the breakdown of thermostat types (pager/wifi) of all thermostats and newly installed devices in FY 2017. Although Wifi thermostats only account for 8% of the total thermostats, almost 2 out of 3 newly installed thermostats[30] are WiFi-enabled in FY2017.

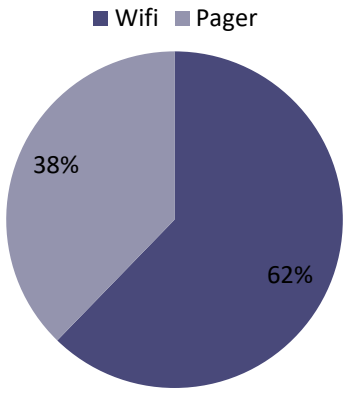

Figure 5-14: Smart Thermostat – Breakdown by Thermostat Type – FY 2017 New Installs

[30] The numbers of newly-installed thermostats on multi-pager-50% cycling and commercial-pager-50% cycling are estimated.

Table 5-9 summarizes end of FY 2017 participation levels by customer segment and cycling strategy.

Table 5-9: Smart Thermostat – Program Participation by Group, End of FY 2017

Cycling Strategy		Single-family	Multifamily	Commercial	Total
33% Cycling		38661	38880	1962	79503
50% Cycling	Pager	11258	965	192	12415
	WiFi	4606	3181	751	8538
Total		54525	43026	2905	100456

5.3.3 Savings Calculation Methods

CPS Energy provided Frontier with 15-minute interval AMI meter level data from June 1st, 2016 to September 30th, 2016. The table below summarizes the sample size used for analysis:

Table 5-10: Smart Thermostat Sample Size

Dwelling Type	Thermostat Type	Cycling Type	# of sample accounts	# of sample thermostats
Residential	Pager	33%	1319	1467
Residential	Pager	50%	1333	1507
Residential	WiFi	50%	1245	1518
MultiFamily	Pager	33%	1159	1188
MultiFamily	Pager	50%	6	6
MultiFamily	WiFi	50%	24	468
Commercial	Pager	33%	168	487
Commercial	Pager	50%	4	5
Commercial	WiFi	50%	22	101

Frontier produced estimates of total kW and kWh savings and scaled the results to the end of fiscal year participation numbers and new installment numbers to generate EOY program capability and incremental savings.

There are two methodologies used in Smart Thermostat savings estimation. The first is top 3-of-10 baseline method, which is used to estimate kW savings. This methodology can be expressed in the following equation:

$$kW\ savings = original\ baseline\ kW * adjustment\ factor - event\ kW$$

In the equation above:

Original baseline kW: For each event, the previous 10 non-event, non-holiday weekdays were ranked based on kW during the event period. The three days with the highest load during the curtailment period were selected and averaged as the original baseline.

Adjustment factor: The ratio of event day kW versus average 3 baseline days kW during the 15-minute interval right before the event. This ratio was applied to the original baseline kW, intending to make up for variations caused by weather effects and customer operation levels to certain extent.

Event kW: Event day kW during event time period.

The second methodology is fixed-effects panel data analysis regression. This model takes temperature and snapback effect into consideration. The data used is 13:00-19:00, all summer afternoon. The model equation is stated as follows:

$$15\text{-}minute\ kWh\ Consumption_{i,t} = \beta_{0i} + \beta_1 * cdh_t + \beta_2 *\ cdhevent_t + \beta_3 * snapback_t + \sum_{k=4}^{6} \beta k * month + (\sum_{m=7}^{12} \beta m * day\text{-}of\text{-}week +)\ \ \varepsilon_{i,t}$$

In the equation above:

Cdh: cooling degree hours. Balance point is set at 65F.
cdh = max(hourly temperature – 65F, 0)

cdhevent: cooling degree hour and event dummy variable interaction

snapback: dummy variable, 1 if on a post event 1-hour period; 0 otherwise

month: 3 dummy variables indicating month

day-of-week: 6 dummy variable indicating day of week (this set of variables are only applied on commercial types)

For example, for a certain event with temperature at 95F, the average kWh savings for each household during event period is $-\beta_2 * 30 *$ event duration $* 4$. Since β_3 is the estimate for the snapback, net kWh savings for each household would be: $-\beta_2 * 30 *$ event duration $* 4 - \beta_3 * 4$.

5.3.3.1 Coincident Peak (CP) Demand Savings (kW)

To estimate coincident peak demand kW savings, we estimated account-level total demand savings using the top 3-of-10 baseline analysis for each event. An average kW savings of 14 out of 22 high temperature31 events in 2016 was then calculated. To estimate program capability based on end-of-

[31] High temperature threshold is set at 95F.

year and incremental enrollment, we scaled the result to the number of Smart Thermostats at the end of FY 2017 and to the number of new thermostats during FY 2017, respectively.

5.3.3.2 Non-Coincident Peak (NCP) Demand Savings (kW)

Delivered non-coincident peak savings represent selected the maximum event demand savings among FY 2017 events. End of year and incremental estimates of NCP savings were obtained by scaling the delivered NCP to the number of installed devices at the end of FY 2017.

5.3.3.3 ERCOT 4CP Demand Savings (kW)

During summer 2016, 4 of the 22 Smart Thermostat events coincided with ERCOT 4CP events, with a success rate of 100%. To estimate ERCOT 4CP demand savings, we estimated per-account kW savings using top 3-of-10 baseline analysis, selected the four events which coincided with ERCOT 4CP, and multiplied the result by the ERCOT 4CP success rate, which is 100%. For the year-end capability and incremental calculations, we scaled the result to the number of thermostats at the end of FY 2017 and to the number of newly installed thermostats during FY 2017.

5.3.4 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated program impacts during summer 2016 DR events.

2) End of year program capability based on program enrollment at the end of FY 2017; this information is useful for planning purposes.

3) End- of-year program capability based on incremental enrollment during FY 2017; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

5.3.4.1 Estimated Impacts During Summer 2016 DR Events

22 demand response events were called during the summer of 2016 for Smart Thermostat participants. Four of the events called by CPS Energy during the summer of 2016 coincided with the four coincident peak intervals (4CPs) used by ERCOT to allocate transmission costs to load-serving entities. These demand reduction estimates are shown in Figure 5-15[32].

[32] Estimated number of Honeywell thermostats who participated in BYOT program were removed from smart thermostat program.

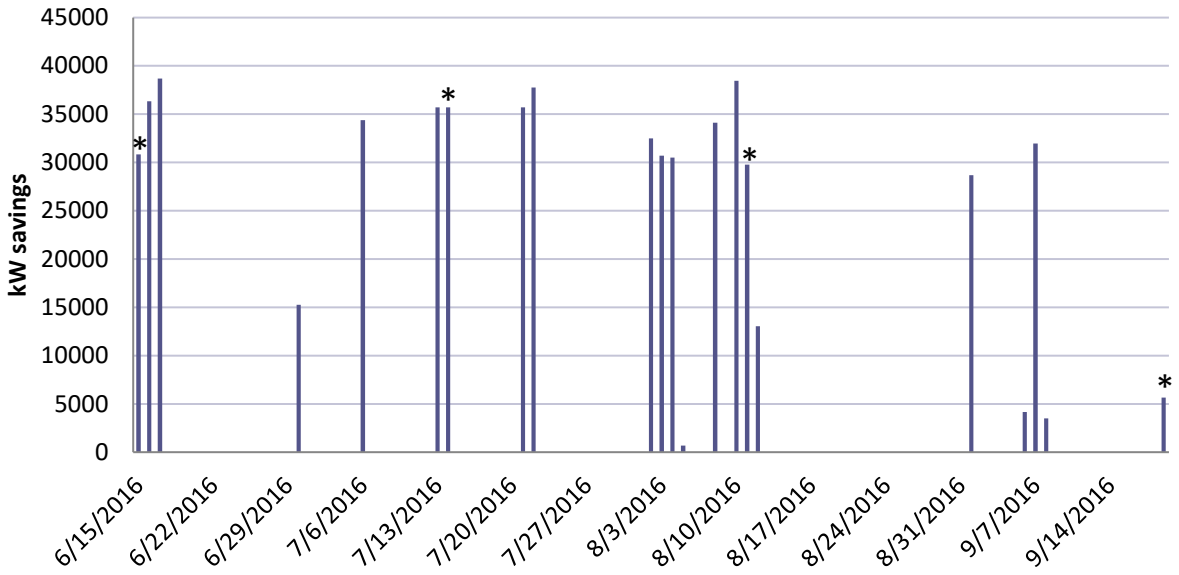

Figure 5-15: Smart Thermostat – Achieved Demand Reduction during Summer 2016 Events

Note: Events coinciding with ERCOT 4CP intervals are designated with a *.

As can be seen from the figure above, the total kW reduction across all summer 2016 events ranged from 696 kW (08/05/2016 event) to 38,691 kW (06/17/2016 event). Almost no load reduction was detected on pager-type devices on 08/05/2016, 09/06/2016 and 09/08/2016 events due to technical issues, thus causing the low load reduction on these days.

The table below shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings actually delivered by the program in FY 2017. Peak demand savings are the average estimated savings during high temperature events; ERCOT 4CP savings are the average estimated savings during ERCOT 4CP events. Non-coincident peak savings are the highest savings achieved during any event.

Table 5-11: Smart Thermostat Gross Energy and Demand Savings – FY 2017 Delivered

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Single-Family Dwellings, 33% Cycling	188,297	10,596	18,213	10,158
Multifamily, 33% Cycling	211,498	8,580	7,634	7,016
Commercial, 33% Cycling	13,041	659	1,101	518
Single-Family Dwellings, 50% Cycling	197,594	7,730	9,524	6,728
Multifamily, 50% Cycling	11,105	443	925	360
Commercial, 50% Cycling	36,039	996	1,294	712
Total	**657,574**	**29,004**	**38,691**	**25,493**

5.3.4.2 End of Year Program Capability

End of year program capability is based on end of year enrollment and events with technical issues or inconsistent calling time are removed. The table below shows the EOY 2017 program capability values.

Table 5-12: Smart Thermostat Gross Energy and Demand Savings – End of Year Capability

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Single-Family Dwellings, 33% Cycling	189,127	11,392	18,215	10,185
Multifamily, 33% Cycling	205,780	8,941	7,434	6,828
Commercial, 33% Cycling	11,638	630	977	462
Single-Family Dwellings, 50% Cycling	201,956	8,513	9,890	8,032
Multifamily, 50% Cycling	18,513	851	1,825	622
Commercial, 50% Cycling	53,325	1,598	1,946	1,466
Total	**680,339**	**31,924**	**40,288**	**27,593**

5.3.4.3 Incremental Impacts

Incremental impacts used for cost-effectiveness analysis are based on gross incremental enrollment; both are shown below.

Table 5-13: Smart Thermostat Gross Energy and Demand Savings – Incremental Impacts

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Single-Family Dwellings, 33% Cycling	1,370	83	132	74
Multifamily, 33% Cycling	11,295	491	408	375
Commercial, 33% Cycling	261	14	22	10
Single-Family Dwellings, 50% Cycling	55,082	2,114	2,364	2,184
Multifamily, 50% Cycling	3,668	162	221	119
Commercial, 50% Cycling	20,379	594	684	560
Total	**92,054**	**3,458**	**3,832**	**3,322**

5.3.4.4 Temperature Bins

Temperature bins may serve as an expedited method for estimating savings in future years. Based on this year's panel data regression, Frontier generated the following temperature bins for the following 4 categories[33]: pager-multifamily-33% cycling, pager-residential-33% cycling, pager-residential-50% cycling and wifi-residential-50% cycling.

Table 5-14: Temperature bin kW savings per Household for Smart Thermostat – 4 Categories

Temperature	Pager-Multifamily-33% cycling	Pager-Residential-33% cycling	Pager-Residential-50% cycling	Wifi-Residential-50% cycling
90	0.16	0.19	0.30	0.68
91	0.17	0.20	0.31	0.71
92	0.18	0.21	0.32	0.73
93	0.18	0.22	0.33	0.76
94	0.19	0.23	0.34	0.79
95	0.20	0.23	0.36	0.81
96	0.20	0.24	0.37	0.84
97	0.21	0.25	0.38	0.87
98	0.22	0.26	0.39	0.90
99	0.22	0.26	0.40	0.92
100	0.23	0.27	0.42	0.95
101	0.24	0.28	0.43	0.98
102	0.24	0.29	0.44	1.00
103	0.25	0.30	0.45	1.03
104	0.26	0.30	0.46	1.06
105	0.26	0.31	0.47	1.09

For example, for a 95F event, the kW savings for wifi-residential-50% cycling would be 0.81 kW. Other categories can be estimated in similar manner.

5.3.5 Recommendations

Frontier makes the following recommendations for the Smart Thermostat program.

- To improve program cost effectiveness, concentrate marketing toward Wifi enabled 50% cycling in all customer segments.
- Evaluate the load reduction signal sending success ratio for pager thermostats. For some events, they tend to have less savings than WiFi customers, holding other situations (same cycling and same dwelling type) same.

[33] Frontier did not generate temperature bin for the rest of the categories due to lack of statistically solid sample size for those categories.

5.4 HOME MANAGER PROGRAM

5.4.1 Overview

Launched in 2012, Home Manager is a comprehensive electric load monitoring and direct load control program. This system controls three types of devices: HVAC units, electric water heaters, and pool pumps. When CPS Energy calls an event, all Home Manager thermostats are adjusted upward by three degrees from their pre-event set points. Water heaters and pool pumps are powered off for the duration of the event. Customers have the ability to reset their thermostat set points or drop completely out of the event at any time. In summer 2016, CPS Energy successfully called 12 test events and 8 additional events, ranging from 1 to 1.93 hours in duration. By 01/31/2017, total participation in Home Manager program was 21,710[34].

5.4.2 Participation Trends

The following figure shows the number of participants during each event in summer 2016.

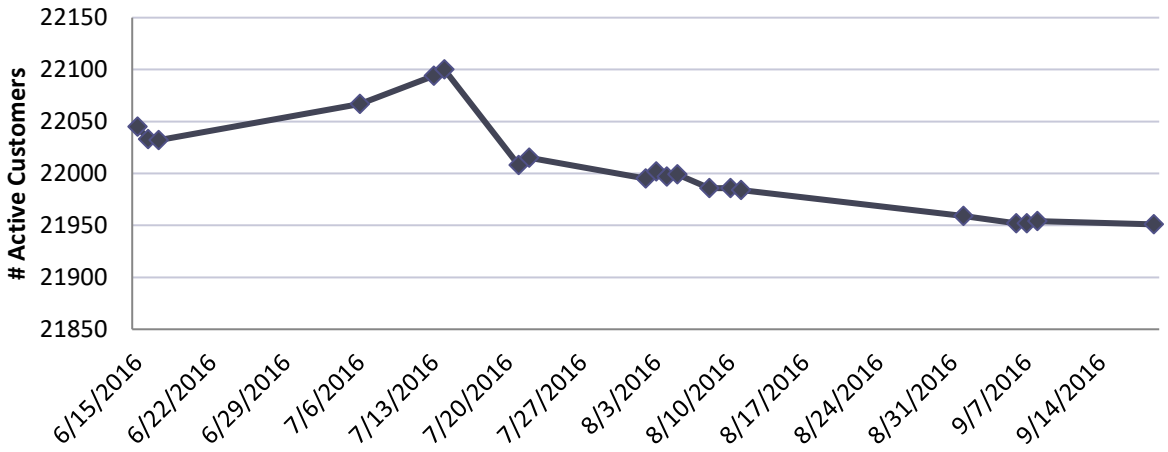

Figure 5-16: Home Manager – Participation Trend

Although there was a slight drop in customer participation after mid-July, the overall number of participants remained stable, ranging from 21,951 to 22,100 households.

5.4.3 Event kW and kWh Savings Methodology

CPS Energy provided Frontier with overall aggregated interval meter data of Home Manager program. Frontier produced estimates of total kW and kWh savings and scaled the results to the end of the fiscal

[34] After the end of FY 2017, CPS Energy cleaned and removed 2,090 non-communicating accounts. Therefore, the adjusted customer number is 19,620.

year participation numbers and new installment numbers to generate EOY program capability and incremental savings.

A top 3-of-10 baseline method was applied to estimate kW savings. The equation is stated as follows:

$$kW\ savings = original\ baseline\ kW * adjustment\ factor - event\ kW$$

In the equation above:

Original baseline kW: For each event, the previous 10 non-event, non-holiday weekdays were ranked based on kW during the event period. The three days with the highest load during the curtailment period were selected and averaged as the original baseline.

Adjustment factor: The ratio of event day kW versus average 3 baseline days kW during the ten minutes before the event until five minutes before the event period[35]. This ratio was applied to the original baseline kW, intending to make up for variations caused by weather effects and customer operation levels to some extent.

Event kW: Event day kW during event time period.

Frontier also employed a linear regression model to quantify the kWh savings using 5-minute aggregated energy consumption data from Home Manager program. This model takes temperature and snapback effect into consideration. The model equation is stated as follows:

$$Consumption_t = \beta_0 + \beta_1 * cdh_t + \beta_2 * event_t + \beta_3 * testevent_t + \beta_4 * snapback_t + \beta_5 * testevent\text{-}snapback_t + \varepsilon_{i,t}$$

In the equation above:

Cdh: cooling degree hours. Balance point is set at 65F.
cdh = max(hourly temperature – 65F, 0)

event: dummy variable, 1 if on an non-test event period; 0 otherwise

testevent: dummy variable, 1 if on an test event period; 0 otherwise

snapback: dummy variable, 1 if on a post non-test event 1-hour period; 0 otherwise

testevent-snapback: dummy variable, 1 if on a post test event 1-hour period; 0 otherwise

$-\beta_2$ is the estimate for 5-minute kW savings during non-test events period. $-\beta_3$ is the estimate for 5-minute kW savings during test events period. β_4 is the estimate for 5-minute kW non-test event snapback during 1-hour post event period. β_5 is the estimate for 5-minute kW test event snapback

[35] 5 minute interval immediately before event start was avoided due to concerns of possible timing error. For example, some events might be called 1 minute or a few seconds before the scheduled time due to slight timing error of different clocks, and this might potentially compromise adjustment ratio calculation.

during 1-hour post event period. Thus the total kWh savings for summer 2016 Home Manager program is $-\beta_2$ * total non-test event hours – β_3 * total test event hours – β_4 * 1 (non-test event snap back hour) – β_5 * 1 (test event snap back hour).

5.4.3.1 Coincident Peak Demand Savings (kW)

To estimate coincident peak demand kW savings, we estimated program-level total demand savings using the top 3-of-10 baseline analysis for each event. An average kW savings of 14 out of 20 high temperature36 events in 2016 was then calculated. To estimate program capability based on end-of-year and incremental enrollment, we scaled the result to the number of active premises at the end of FY 2017 and to the number of new participants during FY 2017, respectively.

5.4.3.2 Non-Coincident Peak (NCP) Demand Savings (kW)

To estimate delivered non-coincident peak savings, Frontier estimated program-level total demand savings using the top 3-of-10 baseline analysis for each event. We then selected the single event with the highest savings. For the year-end capability and incremental calculations, we scaled the result to the number of active premises at the end of FY 2017 and to the number of new participants during FY 2017, respectively.

5.4.3.3 ERCOT 4CP Demand Savings (kW)

During summer 2016, four of the twenty Home Manager events coincided with ERCOT 4CP events, including one non-test event and three test events, for a success rate of 91.7%[37]. To estimate ERCOT 4CP demand savings, we estimated program-level per-event kW savings using top 3-of-10 baseline analysis, selected the four events which coincided with ERCOT 4CP, and multiplied the result by the ERCOT 4CP success rate. For the year-end capability and incremental calculations, we scaled the result to the number of active premises at the end of FY 2017 and to the number of new participants during FY 2017 respectively.

5.4.4 Impact Analysis Results

For demand response programs, we present impacts in three ways:

1) Estimated Achieved program impacts during summer 2016 called DR events.

2) End-of-year program capability based on program enrollment at the end of FY 2017; this information is useful for planning purposes.

3) End-of-year program capability based on incremental enrollment during FY 2017; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.

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[36] High temperature threshold is set at 95F.

[37] The July 14th 4CP interval is 16:15-16:30, while the Home Manager event starts at 16:20, meaning it only coincided with 2/3 of 4CP event on that day.

5.4.4.1 Estimated Impacts during Summer 2016 DR Events

Using the top 3-of-10 methodology, in summer 2016, the per-participant demand reduction achieved through this program during high-temperature events called by CPS Energy averaged 1.70 kW. The total impacts of events ranged from 24,980 kW (9/1 event) to 42,601 kW (6/17 event). Four of the events coincided with the four coincident peak intervals (4CPs) used by ERCOT to allocate transmission costs to load-serving entities[38]. These demand reduction estimates are shown in the following figure.

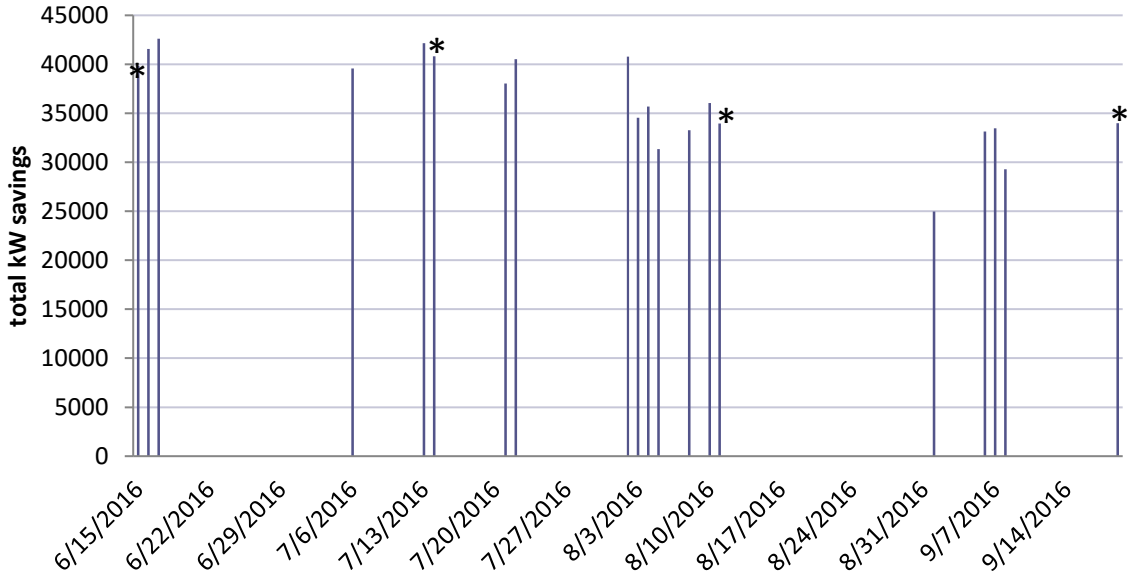

Figure 5-17: Home Manager – Achieved Demand Reduction during Summer 2016 Called Events

Note: Events coinciding with ERCOT 4CP intervals are designated with a *.

The per-participant per-event energy savings averaged 1.77 kWh with later snapback of 0.70 kWh. Thus net energy savings per-participant per event is 1.07 kWh. Annual achieved total net energy savings for the Home Manager program is estimated at 470,090 kWh.

Table 5-15: Home Manager Gross Energy and Demand Savings – FY 2017 Delivered

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Reduction (kW)
Total	470,090	37,429	42,601	33,752

[38] The July 14th 4CP interval was 16:15-16:30, while the Home Manager event started at 16:20, meaning it only coincided with 2/3 of 4CP event on that day. So the 4CP kW savings is calculated by using July 14th event kW savings multiplied by 2/3.

5.4.4.2 End of Year Program Capability

Based on a total of 21,710[39] customers at the end of FY2017, the Home Manager program was capable of providing the energy and demand savings shown in the table below. End-of-year capability is less than delivered savings due to declining net enrollment in the program.

Table 5-16: Home Manager Gross Energy and Demand Savings – End of Year Capability

Measure	Energy Savings (kWh)[40]	Peak Demand Savings (kW)[41]	Non-Coinc. Demand Savings (kW)[42]	ERCOT 4CP Demand Reduction (kW)[43]
Total	463,807	36,896	41,978	33,282

5.4.4.3 Incremental Impacts

Incremental impacts used for cost-effectiveness analysis are based on gross incremental enrollment. 1,334[44] new customers joined the Home Manager program between 2/1/2016 and 1/31/2017. The results are shown below.

Table 5-17: Home Manager Gross Energy and Demand Savings – Incremental Impacts

Measure	Energy Savings (kWh)[45]	Peak Demand Savings (kW)[46]	Non-Coinc. Demand Savings (kW)[47]	ERCOT 4CP Demand Reduction (kW)[48]
Total	28,499	2,267	2,579	2,045

5.4.5 Recommendations

Due to the intrinsic temperature setting algorithm by Home Manager system, load shed rebounds quickly, usually after 20 minutes. This means that the longer event lasts, the lower the average kW savings will be, since savings are diminished in the latter part of each event period. Thus, for the Home Manager program, shorter event duration (1.5 hours or less) is preferred as a means of achieving greater average demand savings.

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[39] After the end of FY 2017, CPS Energy cleaned and removed 2,090 non-communicating accounts. Therefore, the adjusted customer number is 19,620.
[40] 463,807 kWh = per-participant energy savings achieved during event * # of events called in 2016 * year-end customer counts – per-participant energy snapback 1 hour after event * # of events called in 2016 * year-end customer counts
[41] 36,896 kW = 1.70 * year-end customer counts
[42] 41,978 kW = per participant savings on NCP day * year-end customer counts
[43] 33,282 kW = average kW savings on 4 events coinciding with ERCOT 4CP per participant * year-end customer counts * 91.7% success rate
[44] January 2017 newly joined customer number is estimated, while the rest 11 months customer number is actual.
[45] 28,499 kWh = per-participant energy savings achieved during event * # of events called in 2016 * gross customer increase – per-participant energy snapback 1 hour after event * # of events called in 2016 * gross customer increase
[46] 2,267 kW = 1.70 kW * gross customer increase
[47] 2,579 kW = per-participant kW savings on NCP event day in 2016 * gross number increase
[48] 2,045 kW = average per-participant kW savings on 4CP days in 2016 * 91.7% success rate * gross number increase

5.5 BRING YOUR OWN THERMOSTAT (BYOT) PROGRAM

5.5.1 Overview

BYOT (Bring Your Own Thermostat) is a relatively new program that integrates customers' own thermostats with load curtailment events. It began in FY 2015, when CPS Energy partnered with Nest Labs to implement the Rush Hour Rewards (RHR) pilot program for customers with Nest thermostats. Rush Hour Rewards uses a combination of pre-cooling in anticipation of a 'rush hour' – a demand response event initiated by CPS Energy – and air conditioner cycling during the events to achieve load reduction. Nest RHR events are notified a day in advance, and each event lasts three hours. Because of Nest's 'learning' capabilities, reductions may vary based on whether the home is occupied at the time of the event, or other variables. More information on Nest's Rush Hour Rewards (RHR) program is available from the Nest Labs website.[49]

Starting in FY 2016, CPS Energy began incorporating existing Nest RHR customers into a more broadly defined Bring Your Own Thermostat (BYOT) program,[50] which offers similar incentives to customers who self-install any of several qualifying thermostats. These include Honeywell thermostats that operate in a manner similar to those installed under the existing Smart Thermostat program, and EnergyHub thermostats that operate in a manner similar to those installed under the existing Home Manager program.

The key differentiator of BYOT, relative to Smart Thermostat and Home Manager, is that the customer purchases and installs the qualifying thermostat under BYOT, reducing direct install costs otherwise incurred by CPS Energy.

CPS Energy typically passes these savings on to the customer via a one-time credit of $85 upon enrollment in the program, plus a $30 bill credit at the end of each summer for participating in the program. This year, CPS Energy also offered a retail credit of $150 toward customers' purchase of qualifying thermostats from participating vendors, in a late November through end of January promotion.[51]

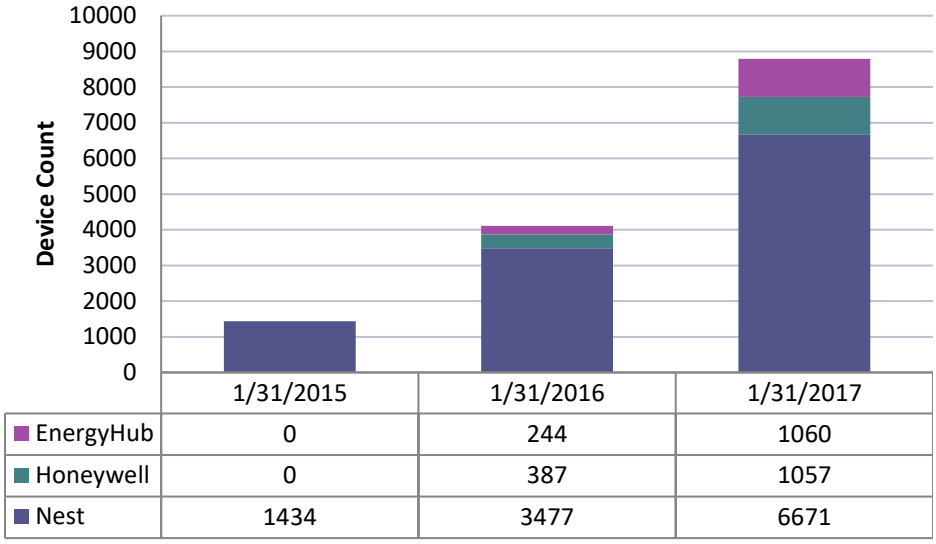
In FY 2017, customers with Nest, EnergyHub and Honeywell thermostats participated in BYOT curtailment events with different events and cycling strategies. EnergyHub thermostats share the same events with those in Home Manager program and operate similarly, while Honeywell thermostats share the same events with those in Smart Thermostat program and operate similarly.

[49] Nest Support. *What is Rush Hour Rewards?* Online. Available: https://nest.com/support/article/What-is-Rush-Hour-Rewards. Accessed March 8, 2016.
[50] CPS Energy markets this program as the My Thermostats Rewards program.
[51] http://newsroom.cpsenergy.com/black-friday-deal-worth-150/

5.5.2 Participation Trends & Demographics Information

5.5.2.1 BYOT Program Level Overall Participation Trends

CPS Energy has rapidly expanded its BYOT customer base since the introduction of the program. Figure 5-18 below shows the number of enrolled BYOT devices by thermostat brand from FY 2015 to FY 2017.



	1/31/2015	1/31/2016	1/31/2017
EnergyHub	0	244	1060
Honeywell	0	387	1057
Nest	1434	3477	6671

Figure 5-18: Bring Your Own Thermostat – Participation Trend (FY 2017)

The vast majority, 73%, of BYOT customers are using Nest thermostats, though there is also rapid growth of EnergyHub thermostats, with the number of devices increased by 334% during FY 2017.

5.5.2.2 Focus: Nest Demographics Breakdown

The number of Nests per household was estimated at 1.23[52] by the end of FY 2017. Figure 5-19 below breaks down Nest RHR customers by premise type over the past two calendar years. 61% of the program enrollees have single family homes, about 7% are apartments, the rest is either unknown or other types such as condo, duplex or townhouses[53].

[52] The ratio 1.23 comes from the 245-household sample with 301 devices. We believe this ratio can serve as a fair point estimate of the population device/household ratio.
[53] This graph is generated using July 2016 demographics data.

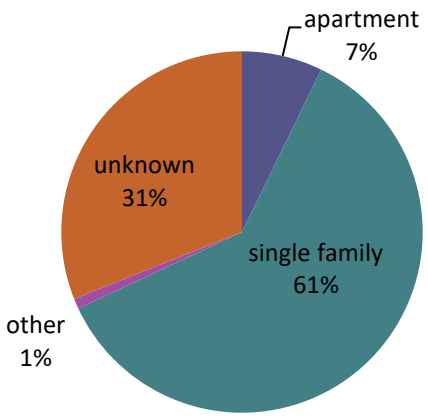


Figure 5-19: Bring Your Own Thermostat – Nest Participation Share by Premise Type

5.5.3 Savings Calculation Method

This section describes Frontier's methods for estimating savings attributable to Nest thermostats participating in the BYOT program. Methods for estimating savings from BYOT-enrolled EnergyHub and Honeywell thermostats are described in the Home Manager and Smart Thermostat sections of this report respectively.[54]

CPS Energy provided Frontier with 15-minute interval AMI meter household level data from a 245-household sample, with 53 apartments and 192 single houses. The time period of the sample data is June 1st, 2016 – September 30th, 2016. Frontier produced household level kW and kWh savings for each dwelling type with the sample, and scaled the results to applicable participation households during each event and at the end of the FY2017.

There are two methodologies used in Nest savings estimation. The first is top 3-of-10 baseline method, which is used to estimate kW savings. For each customer during each event, the previous 10 non-event, non-holiday weekdays were ranked based on total kWh during the event period. The three days with the highest kWh during the curtailment period were selected and averaged as a calculated baseline. An adjustment factor of the average kWh during an event day from 2 hours before the event until 1 hour before the event[55] divided by the average kWh during three selected baseline days may be applied to the calculated baseline to account for weather effects and customer operation levels on the event day.

The second methodology is fixed-effects panel data analysis regression. This is used to quantify kWh savings during summer 2016 RHR events period and generate a time-temperature-matrix (TTM), which may be used in expediting savings calculation in future years. Due to the unique algorithm of Nest thermostat, there is a 1-hour pre-cool period and later snapback effect. Fixed effects panel data model is

[54] For EnergyHub, since there is only BOY and EOY participation number data for EnergyHub (244 and 1060 respectively), no per-event participation number data available, we assume the participation number for the whole summer 2016 is the average, 652.
[55] The 1-hour period right before the event was the pre-cool period, therefore was not adopted as the adjustment factor period.

capable of taking pre-cool, snapback and temperature effect into consideration. The model equation is stated as follows:

$$15\text{-}minute\ per\ household\ kWh_{i,t} =$$

$$\beta_{0,i} + \beta_1 * cdh_t + \beta_2 * june_t + \beta_3 * july_t + \beta_4 * august_t + \sum_{k=5}^{27} \beta k\ * hour_t + \beta_{28} * weekday\text{-}or\text{-}not_t + \beta_{29} * cdheventhour1_t + \beta_{30} * cdheventhour2_t + \beta_{31} * cdheventhour3_t + \beta_{32} * precool_t + \beta_{33} * snapback_t + \varepsilon_{i,t}$$

In the equation above:

Cdh: cooling degree hour, max(0,hourly temp – 65)

June, july, august: dummy variables indicating month

Hour: 23 dummy variables indicating hour of day

Weekday or not: dummy variable, 1 = weekday; 0 = holiday or weekends

Cdheventhour1,2,3: cooling degree hour and event hour interaction

Precool: dummy variable indicating 1-hour precool period; 1= precool period; 0 = other

Snapback: dummy variable indicating 6-hour snapback period; 1= snapback period; 0 = other

For example, for a certain event, if the first event hour temperature is 95F (cdh = 30), 96F (cdh = 31) for the second event hour temperature and 97F (cdh = 32) for the third, then the average kWh savings for each household during event period is $(-30\beta_{29} – 31\beta_{30} – 32\beta_{31})*4$. Since β_{32} is the estimate for precool period on a 15-minute basis and β_{33} is the estimate for snapback period on a 15-minute basis. The net kWh savings for each household on this certain event is $(-30\beta_{29} – 31\beta_{30} – 32\beta_{31})*4- \beta_{32}*4 * 1 - \beta_{33}*4* 6$.

In other words, if given the hourly temperature for a certain event, this model can estimate the kW savings for each hour for that event. This can be tabulated into a time-temperature-matrix (TTM) table, which will be shown in the impact results section of the report.

5.5.3.1 Energy Savings (kWh)

In FY 2016, Frontier employed billing analysis to quantify the electricity and gas savings attributable to installation of a Nest thermostat and enrollment in the Nest RHR program. Frontier's model found that the presence of a Nest thermostat reduced electricity consumption by 51 kWh per household per month, around 3.2% of conservation effect. Frontier consider this number is still valid this year, therefore continues using 51 kWh per household per month as year-round energy savings.

To estimate energy savings during DR events, Frontier employed fixed effects panel data model analysis described earlier to quantify the electricity energy savings in Nest RHR events in summer 2016.

5.5.3.2 Coincident Peak (CP) Demand Savings (kW)

To compute coincident peak (CP) demand savings, we estimated per-household demand savings using the top 3-of-10 baseline analysis. For each event, the per-household demand savings is multiplied by the total number of household at that event. The claimed achieved CP demand savings is the average kW savings across all events. Scaling the average kW savings by the EOY customer count and newly installed customer count yield EOY and incremental CP demand savings.

5.5.3.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Delivered non-coincident peak savings represent selected the maximum event demand savings among FY 2017 events. End of year and incremental estimates of NCP savings were obtained by scaling the delivered NCP to the number of installed devices at the end of FY 2017.

5.5.3.4 ERCOT 4CP Demand Savings (kW)

During summer 2016, 4 of the 14 Nest events coincided with ERCOT 4CP events, with a rate of success in hitting the event of 100%. To estimate ERCOT 4CP demand savings, we estimated per-household kW savings using top 3-of-10 baseline analysis, selected the four events which coincided with ERCOT 4CP, and multiplied the result by the ERCOT 4CP success rate, which is 100%. For the year-end capability and incremental calculations, we scaled the result to the number of active premises at the end of FY 2017 and to the number of new participants during FY 2017.

5.5.4 Impact Analysis Results

For demand response programs, we present impacts in four sections:

1) Estimated program impacts during summer 2016 DR events.
2) End of year program capability based on program enrollment at the end of FY 2017; this information is useful for planning purposes.
3) End of year program capability based on incremental enrollment during FY 2017; this information is used for program benefit-cost analysis, consistent with the methods used for energy efficiency programs.
4) Time-Temperature Matrix for future estimation use

5.5.4.1 Estimated Impacts During Summer 2016 DR Events

14 demand response events were called during the summer of 2016 for Nest participants; for EnergyHub participants, 20 events were called.[56] The impacts of events ranged from 620 kW (8/5 event) to 7,088 kW (9/1 event). Four of the called events coincided with the four coincident peak intervals

[5656] EnergyHub participants were called in synchronization with Home Manager participants, and 20 events were called for Home Manager program in summer 2016.

(4CPs) used by ERCOT to allocate transmission costs to load-serving entities. These demand reduction estimates are shown in Figure 5-20.

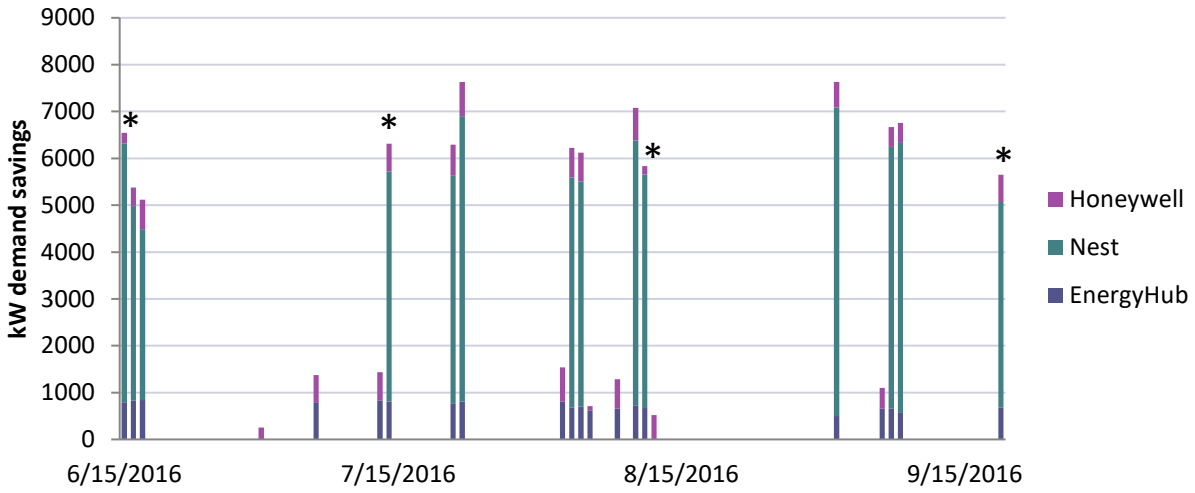


Figure 5-20: Bring Your Own Thermostat – Achieved Demand Reduction during summer 2016 DR Events

Note: Events coinciding with ERCOT 4CP intervals are designated with a *.

For Nest thermostats, the per-participant net energy savings achieved during events called by CPS Energy averaged 0.33 kWh per device, after subtracting pre-cool and snapback period energy over-usage. This yields achieved annual energy savings of 20,002 kWh. For EnergyHub, the achieved annual energy savings is 8,993 kWh.[57] For Honeywell, the achieved annual energy savings is 14,787 kWh.[58]

The table below shows estimated energy, peak demand, non-coincident peak demand, and ERCOT 4CP demand savings actually delivered by the program in FY 2017. For each type of thermostat, peak demand savings are the average estimated savings achieved across all events; ERCOT 4CP savings are the average estimated savings during ERCOT 4CP events.[59] Non-coincident peak savings are the highest savings achieved during any event.

[57] EnergyHub achieved energy savings = average # of participants during event period * kWh savings per event * 20 events = 652*0.69*20. Frontier generated estimated EnergyHub kWh savings per event by using FY 2017 Home Manager kWh savings * energy saving HVAC/household ratio generated in FY 2016.

[58] Honeywell achieved energy savings estimate = estimated average # of participants during event period * kWh savings per event * 22 events

[59] For July 14th Energy Hub event, it only coincides with 2/3 of the ERCOT 4CP, since the events starts at 16:20, while the 4CP period is 16:15-16:30. Frontier discounted savings on that day by 2/3.

Table 5-18: BYOT Gross Energy and Demand Savings – FY 2017 Delivered

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	Demand Reduction during 4CPs
Nest	2,524,624[60]	5,220	6,590	4,955
EnergyHub	8,993	742	843	670
Honeywell	14,787	517	727	393
Total	**2,548,404**	**6,479**	**8,160**	**6,017**

5.5.4.2 End of Year Program Capability

End of year program capability is based on end of year enrollment; both are shown in the table below.

Table 5-19: BYOT Gross Energy and Demand Savings – End of Year Capability

Measure	End of Year Enrollment	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Nest	6,671	3,319,229	8,036	9,824	7,643
EnergyHub	1,060	14,620	1,172	1,371	1,089
Honeywell	1,057	21,648	829	926	858
Total	**8,788**	**3,355,497**	**10,037**	**12,121**	**9,590**

[60] Estimated achieved kWh savings for Nest = (start of year count + end of year count)/2 * 51kWh (kWh savings per household per month) * 12 (months) / 1.23 (household/device ratio)

5.5.4.3 Incremental Impacts

Incremental impacts used in benefit-cost analysis are based on gross incremental enrollment during the program year; both are shown in the table below.

Table 5-20: BYOT Gross Energy and Demand Savings – Incremental Impacts

Measure	Gross Incremental Enrollment	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Nest	3,438	1,710,615	4,142	5,063	3,939
EnergyHub	812	11,199	898	1,050	834
Honeywell	670	13,722	525	587	544
Total	**4,920**	**1,735,536**	**5,565**	**6,700**	**5,317**

5.5.4.4 Time-Temperature Matrix

A Time-Temperature Matrix (TTM) may serve as an expedited way to estimate savings in the future. Based on this year's panel data regression, Frontier generated the following TTM for Nest thermostats in apartments and single family homes, as can be seen in Table 5-21 and

Table 5-22 below:

Table 5-21: Household level TTM for Apartment Dwelling Type

Temperature	1st hour	2nd hour	3rd hour	Average
88	0.71	0.55	0.39	0.55
89	0.74	0.58	0.41	0.57
90	0.77	0.60	0.42	0.60
91	0.80	0.63	0.44	0.62
92	0.83	0.65	0.46	0.65
93	0.86	0.67	0.48	0.67
94	0.89	0.70	0.49	0.69
95	0.92	0.72	0.51	0.72
96	0.95	0.75	0.53	0.74
97	0.98	0.77	0.54	0.77
98	1.01	0.79	0.56	0.79
99	1.04	0.82	0.58	0.81
100	1.08	0.84	0.59	0.84
101	1.11	0.87	0.61	0.86
102	1.14	0.89	0.63	0.89
103	1.17	0.91	0.65	0.91
104	1.20	0.94	0.66	0.93
105	1.23	0.96	0.68	0.96

Table 5-22: Household level TTM for Single Family Dwelling Type

Temperature	1st hour	2nd hour	3rd hour	Average
88	1.40	0.93	0.65	0.99
89	1.46	0.97	0.68	1.03
90	1.52	1.01	0.71	1.08
91	1.58	1.05	0.74	1.12
92	1.64	1.09	0.76	1.16
93	1.70	1.13	0.79	1.21
94	1.76	1.17	0.82	1.25
95	1.83	1.21	0.85	1.29
96	1.89	1.25	0.88	1.34
97	1.95	1.29	0.90	1.38
98	2.01	1.33	0.93	1.42
99	2.07	1.37	0.96	1.47
100	2.13	1.41	0.99	1.51
101	2.19	1.45	1.02	1.55
102	2.25	1.49	1.05	1.60
103	2.31	1.53	1.07	1.64
104	2.37	1.57	1.10	1.68
105	2.43	1.61	1.13	1.72

For example, on a certain 3-hour period event, if the 1st hour temperature is 92F, 2nd hour temperature is 94F, and the 3rd hour temperature is 95F, the average household level kW savings estimate for a single family home would be (1.64 + 1.17 + 0.85)/3 = 1.22 kW. The apartment kW savings can be interpreted in the similar manner.

5.5.5 Recommendations

Frontier provides the following recommendations for the BYOT program:

- For Nest customers, there are around 30% of customers with dwelling types “unknown”. The estimation accuracy might be improved if more customers dwelling type information is available in the future. Plus, if there are any commercial type customers, incorporating commercial type customers in the estimation process will also improve the analysis.
- For the Nest program, currently all the events last 3 hours, with a start time either on 2:30 or 3:00. Trying out events with different start time and duration in the future will help improve the program flexibility.
- Customers have begun to participate in WeatherBug program in FY 2017. The WeatherBug program is an in-door temperature setting algorithm that can be applied to all kinds of thermostats. Studying how this algorithm affects the savings might potentially be helpful in the future.

6. RENEWABLE ENERGY PROGRAMS

6.1 SUMMARY OF RENEWABLE ENERGY IMPACTS

CPS Energy offered the following renewable energy programs in FY 2017:

- Solar Initiative – Residential and Commercial & Schools - offers incentives for the installation of both solar photovoltaic systems and solar water heaters.
- SolarHostSA Pilot - offers residential and commercial customers a bill credit for hosting a third party owned solar energy system on their rooftop.
- Roofless Solar Pilot - enables residential and commercial customers to purchase shares of a large community solar installation and to be credited on their electric bill for a share of the energy produced by that system.

The contribution of each renewable energy program to peak demand, non-coincident peak demand, and energy savings are shown the follow figures.

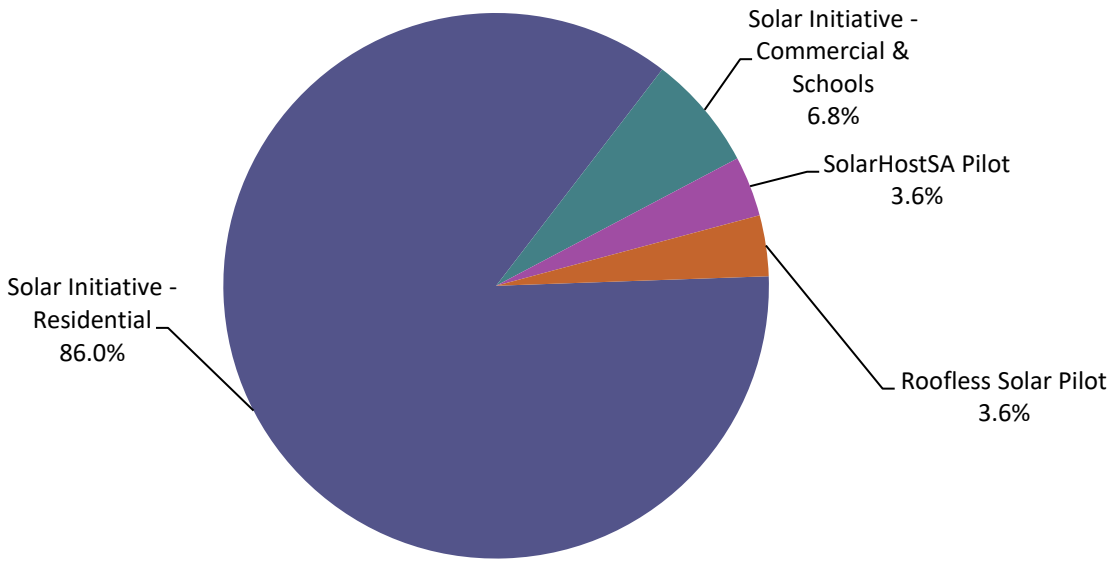


Figure 6-1: Summary of Renewable Energy Impacts – Peak Demand (kW) by Program

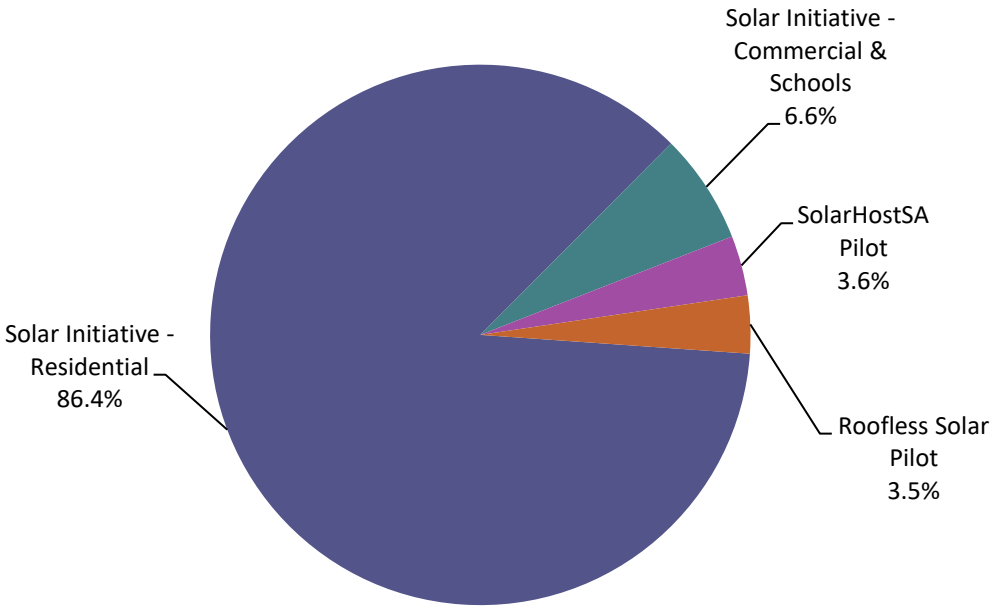


Figure 6-2: Summary of Renewable Energy Impacts – Non-Coincident Peak Demand (kW) by Program

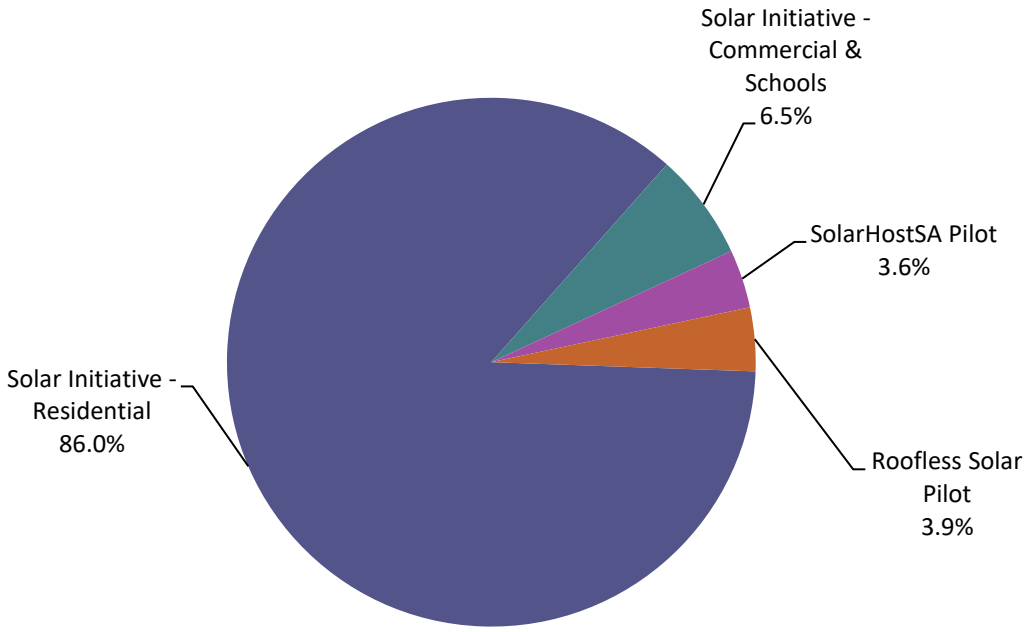


Figure 6-3: Summary of Renewable Energy Impacts – Energy (kWh) by Program

6.2 SOLAR INITIATIVE - RESIDENTIAL PROGRAM

6.2.1 Overview

CPS Energy offers rebates for residential solar photovoltaic (PV) systems. In December 2015, CPS Energy announced an additional commitment of $30 million to its solar rebate programs, to be available in three tranches to residential and commercial solar projects alike:

- Tranche 1 – first $10 million at a Rebate Level of $1.20 per watt
- Tranche 2 – next $10 million at a Rebate Level of $1.00 per watt
- Tranche 3 – last $10 million at a Rebate Level of $0.80 per watt

Solar projects were rebated based on the applicable rebate tier at the time of application. Some solar rebates were paid at higher rebate levels; these were projects that applied for and were approved for solar rebates before the tranche system came into effect. Table 6-1 presents a summary of the number and capacity of residential solar projects at various rebate levels awarded during FY 2017.

Table 6-1: Residential Solar Rebates in FY 2017

Rebate Level	# of Projects	Capacity (kWdc)	Rebated Amount
$1.60	1,587	12,573	$17,010,375
$1.20	1,084	7,553	$7,697,425
$1.00	889	6,750	$5,721,155
$0.80	715	5,487	$3,685,551
Total	**4,275**	**32,363**	**$34,114,507**

All residential solar PV systems were required to be installed by a CPS Energy-registered contractor. Rebates were not available for leased equipment. The current rebate limits of $25,000 for residential projects and $80,000 for commercial remain in place. Rebates are also capped at 50% of project cost.

All systems are required to be interconnected to the CPS Energy distribution system on the customer's side of the meter in a net metering arrangement. Systems must be permitted, pass all required inspections, and comply with CPS Energy's requirements for interconnection.

In FY 2017, 4,275 residential solar PV systems totaling 32,363 kWdc were installed, and $34.1 million in rebates distributed. The average residential solar PV system size was 7.98 kWdc. The figure below summarizes the residential solar PV program history in terms of capacity installed, average system prices and rebate levels annually.

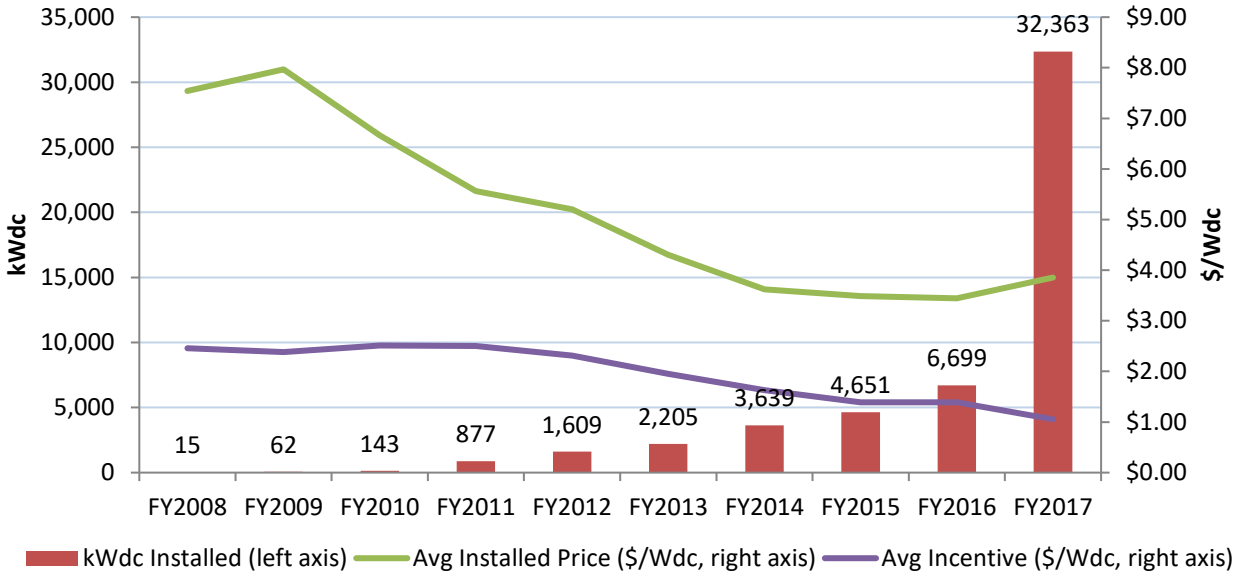


Figure 6-4: Residential Solar PV Program History - Annual Capacity Installed, Average System Price, and Average Rebate Levels

6.2.2 Savings Calculation Methods

The following subsections describe Frontier's approach to estimating savings for residential PV installations.

6.2.2.1 Energy Savings (kWh)

Energy savings estimates were generated via a deemed savings methodology as described in the *CPS Energy Guidebook* provided by Frontier Associates. The method assumes an average production index of 1,402 kWh per kWdc installed among a variety of residential PV systems at various tilts and orientations.

The method is based on modeling the annual energy production from a representative fleet of residential PV systems using the National Renewable Energy Laboratory's (NREL) PVWatts version 5 (released in November 2014) and Typical Meteorological Year version 3 (TMY3) weather data from the San Antonio Kelly Field Air Force Base (Kelly AFB) station.[61] The representative fleet was constructed from a weighted average of 7 different array tilt and orientation combinations, with weightings conforming to expected residential distributions and producing an annual energy production estimate that was consistent with the sum of production estimates for individual systems produced by CPS Energy and stored in the CPS Energy program database.

[61] Frontier examined PV production as modeled using three different San Antonio TMY3 data sources and used Kelly AFB to be consistent with the probabilistic analysis for Demand Savings. Annual energy production estimates generated by PVWatts version 5 have been demonstrated to more closely match measured system performance data, and version 5 addresses concerns that PVWatts version 1 tended to under-predict PV system performance given the default input assumptions. See http://pvwatts.nrel.gov/version_5.php for more information.

6.2.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's approach to estimating peak demand savings utilizes a deemed savings factor of 0.39 kW of coincident peak savings per kWdc installed and is described in the *CPS Energy Guidebook*.

The *CPS Energy Guidebook* methodology utilizes a probabilistic analysis based on modeled system performance during the 20 highest probability summer peak hours. In essence, the approach relates actual historical weather data, day-of-week, and time-of-day variables to ERCOT zonal peak conditions, and applies those historical relationships to TMY3 hourly weather data to estimate the hours in a TMY data file most likely to coincide with hours of high demand in ERCOT's CPS Energy zone. Estimates of CPS Energy's residential PV fleet energy production were derived using PVWatts, and hours associated with high demand in the TMY data were identified. We then calculate a probability-weighted estimate of PV production during those peak hours.

6.2.2.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Non-coincident demand savings represent the maximum kW produced by the modeled representative fleet of residential PV systems installed in FY 2016 in any hour. The *CPS Energy Guidebook* presents a deemed value of 0.804 kW of NCP savings per kWdc installed.

6.2.2.4 ERCOT 4CP Demand Savings (kW)

The ERCOT 4CP demand savings estimate represents the average estimated demand savings produced by the modeled representative fleet of residential PV systems installed in FY 2016 during ERCOT 4CP intervals from 2011-2015. The *CPS Energy Guidebook* presents a deemed value of 0.351 kW of ERCOT 4CP savings per kWdc installed.

6.2.3 Results and Recommendations

The gross energy and demand savings for the Residential Solar Initiative are presented in Table 6-2.

Table 6-2: Residential Solar Initiative Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Residential Solar PV	45,372,393	12,621	26,020	11,359

Frontier's recommendations pertaining to an extended rebate program are:

- A substantially expanded rebate program will require additional administrative effort. Investments toward automating the incentive application process could reduce administrative burdens and speed the process for customers and installers.

- CPS Energy should ensure that interconnection inspectors and/or M&V contractors verify installed equipment in addition to performing a backfeed test when they visit the site, at least for larger installations and for a randomly-selected sample of smaller installations.
- The accuracy of energy savings estimates could be enhanced over time with access to meter data, including data from both solar meters and customer revenue meters.

6.3 SOLAR INITIATIVE – COMMERCIAL & SCHOOLS PROGRAM

6.3.1 Overview

CPS Energy offers rebates for solar photovoltaic (PV) systems installed on commercial and school buildings. In December 2015, CPS Energy announced a commitment of $30 million to its solar rebate programs, to be available in three tranches to residential, commercial and school solar projects alike:

- Tranche 1 – first $10 million at a Rebate Level of $1.20 per watt
- Tranche 2 – next $10 million at a Rebate Level of $1.00 per watt
- Tranche 3 – last $10 million at a Rebate Level of $0.80 per watt

Solar projects were rebated based on the applicable rebate tier at the time of application. Some solar rebates were paid at higher rebate levels; these were projects that applied for and were approved for solar rebates before the tranche system came into effect. Table 6-3 presents a summary of the number and capacity of commercial and school solar projects at various rebate levels awarded during FY 2017.

Table 6-3. Commercial and School Solar Rebates in FY 2017

Rebate Level	# of Projects	Capacity (kWdc)	Rebated Amount
$1.60	56	1,968	$2,559,481
$1.20	5	231	$240,017
$1.00	4	146	$127,537
$0.80	2	149	$104,700
Total	**67**	**2,494**	**$3,031,734**

All commercial and school solar PV systems were required to be installed by a CPS Energy-certified contractor. Rebates were not available for leased equipment. Commercial and school rebates were limited to $80,000 and were capped at 50% of project cost.

All systems are required to be interconnected to the CPS Energy distribution system on the customer's side of the meter in a net metering arrangement. Systems must be permitted, pass all required inspections, and comply with CPS Energy's requirements for interconnection.

In FY 2017, 67 commercial and school solar PV systems totaling 2,494 kWdc were installed, and $3.0 million in rebates distributed. The average commercial/school solar PV system size was 37.2 kWdc. The figure below summarizes the commercial/school solar PV program history in terms of capacity installed, average system prices and rebate levels annually.

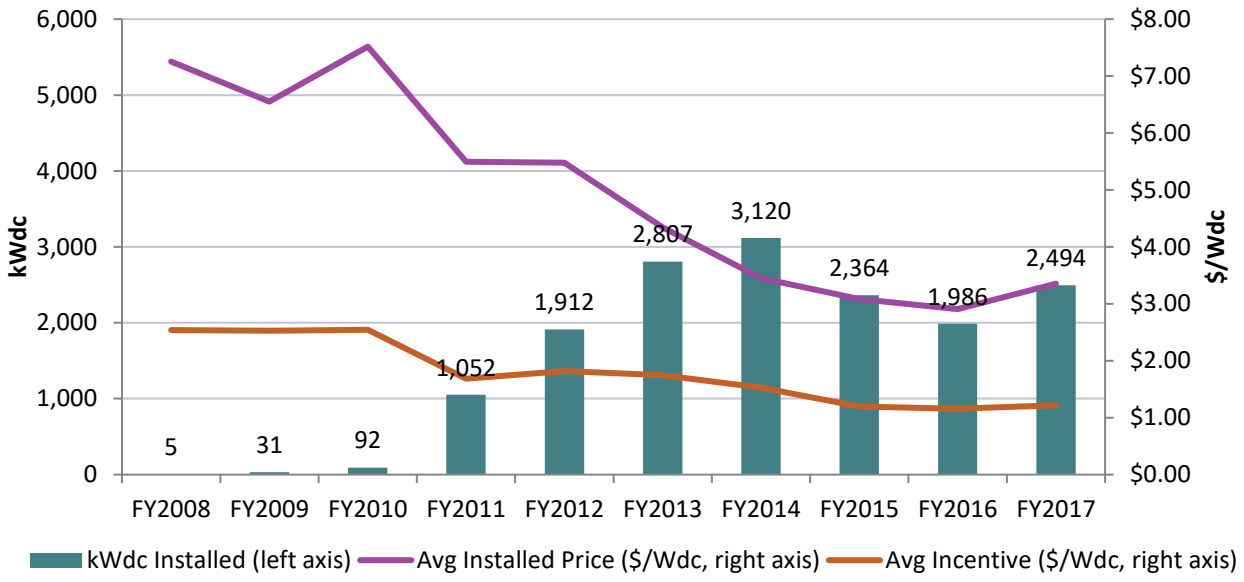


Figure 6-5: Solar Initiative – Commercial and Schools Program History: Annual Capacity Installed, Average System Price, and Average Rebate Levels

6.3.2 Savings Calculation Method

The following subsections describe Frontier's approach to estimating savings for commercial and school PV installations.

6.3.2.1 Energy Savings (kWh)

Energy savings estimates were generated via a deemed savings methodology as described in the *CPS Energy Guidebook* provided by Frontier Associates. The method assumes an average production index of 1,385 kWh per kWdc installed among a variety of commercial and school PV systems at various tilts and orientations.

The method is based on modeling the annual energy production from a representative fleet of commercial/school PV systems using the National Renewable Energy Laboratory's (NREL) PVWatts version 5 (released in November 2014) and Typical Meteorological Year version 3 (TMY3) weather data from the San Antonio Kelly Field Air Force Base (Kelly AFB) station.[62] The representative fleet was constructed from a weighted average of 7 different array tilt and orientation combinations, with weightings conforming to expected commercial/school distributions and producing an annual energy production estimate that was consistent with the sum of production estimates for individual systems produced by CPS Energy and stored in the CPS Energy program database.

[62] Frontier examined PV production as modeled using three different San Antonio TMY3 data sources and used Kelly AFB to be consistent with the probabilistic analysis for Demand Savings. Annual energy production estimates generated by PVWatts version 5 have been demonstrated to more closely match measured system performance data, and version 5 addresses concerns that PVWatts version 1 tended to under-predict PV system performance given the default input assumptions. See http://pvwatts.nrel.gov/version_5.php for more information.

6.3.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's approach to estimating peak demand savings utilizes a deemed savings factor of 0.403 kW of coincident peak savings per kWdc installed and is described in the *CPS Energy Guidebook*.

The *CPS Energy Guidebook* methodology utilizes a probabilistic analysis based on modeled system performance during the 20 highest probability summer peak hours. In essence, the approach relates actual historical weather data, day-of-week, and time-of-day variables to ERCOT zonal peak conditions, and applies those historical relationships to TMY3 hourly weather data to estimate the hours in a TMY data file most likely to coincide with hours of high demand in ERCOT's CPS Energy zone. Estimates of CPS Energy's commercial PV fleet energy production were derived using PVWatts, and hours associated with high demand in the TMY data were identified. We then calculate a probability-weighted estimate of PV production during those peak hours.

6.3.2.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Non-coincident demand savings represent the maximum kW produced by the modeled representative fleet of commercial PV systems installed in FY 2017 in any hour. *CPS Energy Guidebook* presents a deemed value of 0.797 kW of NCP savings per kWdc installed.

6.3.2.4 ERCOT 4CP Demand Savings (kW)

The ERCOT 4CP demand savings estimate represents the average estimated demand savings produced by the modeled representative fleet of commercial PV systems installed in FY 2017 during ERCOT 4CP intervals from 2011-2015. The *CPS Energy Guidebook* presents a deemed value of 0.351 kW of ERCOT 4CP savings per kWdc installed.

6.3.3 Results and Recommendations

The gross energy and demand savings for the Commercial and Schools Solar Initiative are presented below.

Table 6-4: Solar Initiative – Commercial & Schools Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Commercial & Schools Solar PV	3,454,135	1,005	1,988	875

Frontier's recommendations for the Commercial and Schools Solar Initiative are equivalent to those offered for the Residential Solar Initiative, and are outlined in Section 6.2.3.

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6.4 SOLARHOST SA PROGRAM

6.4.1 Overview

Under SolarHostSA, CPS Energy has contracted with a developer to install solar PV systems on residential and commercial rooftops within CPS Energy's service area. Unlike typical customer-owned residential and commercial PV systems, which are interconnected on the customer's side of the utility meter and reduce a customer's metered demand and energy consumption, these systems inject energy directly onto the CPS Energy distribution system. CPS Energy pays the developer a contracted price for energy generated from the systems, and in addition credits host customers 3 cents/kWh generated for the use of their rooftops for this purpose.

The SolarHostSA program thus works as a long-term generation contract for solar energy that is produced locally, on the distribution system. An advantage of the program design is that it enables customers who otherwise could not afford to make an investment in solar PV the opportunity to host such generators and to earn financial rewards for doing so. With appropriate controls built into the inverters on these systems, the program also has the potential to promote distribution system reliability and to respond to utility commands as needed, though these functions have not yet been tested. All installed systems are directly metered by CPS Energy.

By the end of FY 2017, the SolarHostSA program had resulted in the installation of 1,343.9 kWdc of solar capacity on 200 local rooftops. Additional installations are continuing in FY 2018. The figure below shows the cumulative capacity of installations throughout FY 2017.

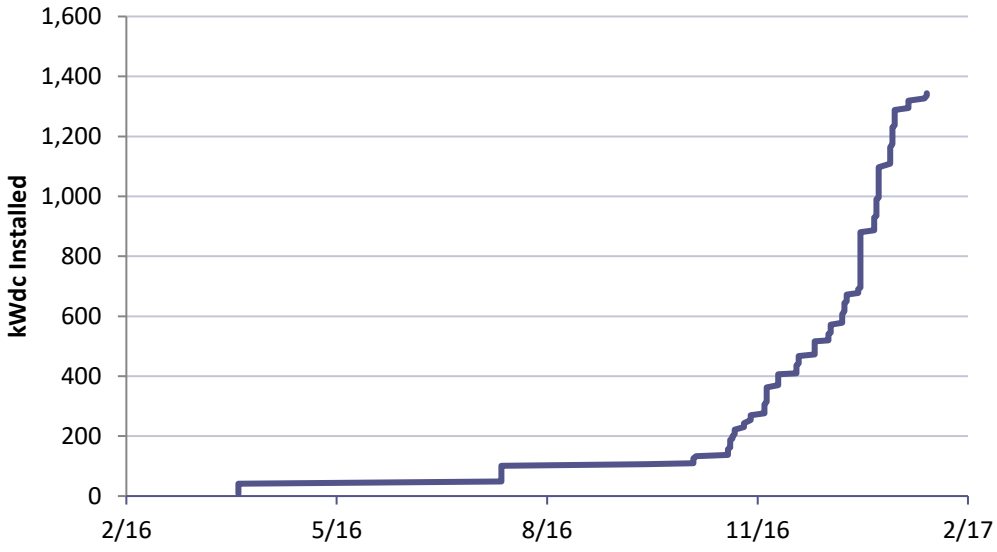

Figure 6-6: SolarHostSA Program - Cumulative Capacity Installed in FY 2017

6.4.2 Savings Calculation Methods

The following subsections describe Frontier's approach to estimating savings for SolarHostSA PV installations.

6.4.2.1 Energy Savings (kWh)

All systems installed via the SolarHostSA program in FY 2017 were hosted by residential customers on residential rooftops. Energy savings estimates were therefore generated via the residential solar deemed savings methodology as described in the *CPS Energy Guidebook* provided by Frontier Associates. The method assumes an average production index of 1,402 kWh per kWdc installed among a variety of residential PV systems at various tilts and orientations.

6.4.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's approach to estimating peak demand savings utilizes a residential solar deemed savings factor of 0.39 kW of coincident peak savings per kWdc installed and is described in the *CPS Energy Guidebook*.

6.4.2.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Non-coincident demand savings represent the maximum kW produced by the modeled representative fleet of residential PV systems installed in FY 2017 in any hour. The *CPS Energy Guidebook* presents a deemed value of 0.804 kW of NCP savings per kWdc installed for residential solar systems.

6.4.2.4 ERCOT 4CP Demand Savings (kW)

The ERCOT 4CP demand savings estimate represents the average estimated demand savings produced by the modeled representative fleet of residential PV systems installed in FY 2017 during ERCOT 4CP intervals from 2011-2015. The *CPS Energy Guidebook* presents a deemed value of 0.351 kW of ERCOT 4CP savings per kWdc installed for residential solar systems.

6.4.3 Results and Recommendations

The gross energy and demand savings for the SolarHostSA program are presented in Table 6-2. These represent the estimated annual energy and demand savings that would have been produced had all systems installed during FY 2017 been operational throughout the fiscal year, and is consistent with how savings are estimated for all energy efficiency programs.

Table 6-5: End-of-Year Capability - SolarHostSA Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
SolarHost SA	1,884,148	524	1,080	472

Actual energy and demand savings achieved during the fiscal year were lower, because systems came online throughout the year and most systems came online only very late in the year. Frontier's estimates

of the actual savings achieved during the fiscal year were as follows: energy savings 252,259 kWh; peak demand savings 39 kW, non-coincident peak demand savings 1,080 kW; ERCOT 4CP demand savings 36 kW. The non-coincident peak figure is comparatively high, relative to the peak and ERCOT 4CP demand figures, because NCP represents the peak capability at any time during the program year, and thus benefitted from the full capacity installed through January 2017. Peak and ERCOT 4CP demand savings estimates were based on capacity in place during the summer peak season, June – September 2016, during which the cumulative capacity installed just exceeded 100 kW.

Frontier's recommendations pertaining to the SolarHostSA program are:

- CPS Energy's SolarHostSA program is new and unique, and has received national attention for its emphasis on providing customers of all income levels with an opportunity to participate in the emerging distributed solar market. It serves in part as a proof of concept of the "utility customer as system host" model.
- The program's cost-effectiveness could be improved via scheduled reductions in the contracted price of energy from newly-installed systems, and indeed, CPS Energy's contract with the developer already includes such reductions. We expect to see improvements in cost-effectiveness as lower-cost generation enters the program.

6.5 ROOFLESS SOLAR PHOTOVOLTAIC PROGRAM

The Roofless Solar program presents a means for some customers who cannot or do not wish to install solar on their own property to purchase a share in a larger "community" solar installation elsewhere and see the benefits monthly on their electric bill.

6.5.1 Overview

CPS Energy contracted with a developer to build a 1,212.6 kWdc single-axis tracking solar photovoltaic system at a site south east of the San Antonio urban core, and provided the developer with a solar rebate designed to be roughly equivalent to those offered in the residential and commercial solar rebate programs. The developer, in turn, passed these rebates on to customers who purchased shares of the community solar system from the developer.

The community solar system became commercially operational on August 26, 2016, with 245 CPS Energy customers owning shares. CPS Energy monitors production from the community system, and offers bill credits to participating customers designed to approximate the value customers would have received had the generation occurred behind the customer's meter, less 15% held in escrow to pay for operations and maintenance on the community solar system.

The aerial photo below shows the completed system. The long rows oriented roughly north-south contain solar panels that follow the sun from east to west as it crosses the sky daily.

Figure 6-7: CPS Energy's 1.213 MW Single-Axis Tracking Roofless Solar PV Installation

6.5.2 Savings Calculation Methods

The following subsections describe Frontier's approach to estimating savings for the Roofless Solar PV installation.

For all values below, Frontier relied on both metered data compiled by CPS Energy of the gross and net energy production from the community solar system and on modeled data designed to represent system performance annually. For the latter, Frontier modeled the community solar system using the National Renewable Energy Laboratory's (NREL) PVWatts version 5 and Typical Meteorological Year version 3 (TMY3) weather data to obtain annual, monthly and hourly estimates of energy production.

6.5.2.1 Energy Savings (kWh)

Actual net energy production from the commercial date of operation to the end of FY 2017 was 784,378 kWh, as metered by CPS Energy. Frontier's estimate of annual energy production obtained via the PVWatts model was 2,049,580 kWh.

6.5.2.2 Coincident Peak (CP) Demand Savings (kW)

Frontier's estimated peak demand savings in accordance with the method described in the *CPS Energy Guidebook*, which takes probability-weighted average of modeled production during the 20 highest probability summer peak hours. In essence, the approach relates actual historical weather data, day-of-week, and time-of-day variables to ERCOT zonal peak conditions, and applies those historical relationships to TMY3 hourly weather data to estimate the hours in a TMY data file most likely to coincide with hours of high demand in ERCOT's CPS Energy zone.

6.5.2.3 Non-Coincident Peak (NCP) Demand Savings (kW)

Non-coincident demand savings represent the maximum kW produced by the modeled community solar system in any hour.

6.5.2.4 ERCOT 4CP Demand Savings (kW)

The ERCOT 4CP demand savings estimate represents the average estimated demand savings produced by the modeled community solar system during ERCOT 4CP intervals from 2011-2015.

6.5.3 Results and Recommendations

The gross energy and demand savings for the Roofless Solar program are presented in Table 6-2.

Figure 6-8. Roofless Solar Program Gross Energy and Demand Savings

Measure	Energy Savings (kWh)	Peak Demand Savings (kW)	Non-Coinc. Demand Savings (kW)	ERCOT 4CP Demand Savings (kW)
Roofless Solar	2,049,580	529	1,041	0

Two characteristics distinguish the performance of the community solar system from other residential, commercial, and SolarHostSA systems. First, the ratio of peak demand savings to non-coincident peak demand savings is greater for the Roofless Solar program. This is the result of the tracking system installed, which enables higher energy and demand yields later in the afternoon during summer, when peak times are most likely to occur. Second, ERCOT 4CP demand savings are not credited toward this installation, essentially because it is viewed by CPS Energy and ERCOT as generation rather than as load, and therefore its performance does not reduce CPS Energy's 4CP cost allocation.

Actual energy and demand savings achieved during the fiscal year were lower, because the system came online in August. Frontier's estimates of the actual savings achieved during the fiscal year were as follows: energy savings 784,378 kWh (from CPS Energy meters); peak demand savings 529 kW, non-coincident peak demand savings 1,041 kW; ERCOT 4CP demand savings 0 kW.

Frontier's recommendations pertaining to the Roofless Solar program are:

- CPS Energy's Roofless Solar program is new and unique, and serves in part as a proof of concept of the selected community solar model.
- Cost-effectiveness could be improved via future capacity additions contracted at lower rebate levels and/or lower bill credits to customers.

7. TOTAL IMPACTS AND COST-EFFECTIVENESS

7.1 NET PROGRAM IMPACTS & COST-EFFECTIVENESS

Program impacts presented in the Residential Energy Efficiency, Commercial Energy Efficiency, and Demand Response sections of this report are gross program impacts (measured at the customer's meter), without any adjustments for distribution losses or Net-to-Gross (NTG) adjustments.

The net program energy savings values shown here and in the executive summary were derived by converting the program-level gross energy savings at the meter to savings at the source using a CPS Energy-provided energy loss factor equal to 5.08%. The net program capacity savings values were derived by converting the program-level gross capacity savings at the meter to savings at the source using a CPS Energy-provided capacity loss factor equal to 8.15%.

The gross energy and capacity savings were further adjusted using the NTG values seen in the below table. These values were provided by CPS Energy and based on previous evaluations, with the exception of the Weatherization program. Based on Frontier experience and industry standards used in Texas, a 100% NTG factor was used for this program.

Overall, CPS Energy's energy efficiency and demand response portfolio produced positive net benefits, resulting in a portfolio-wide benefit-cost ratio of 1.86.

Frontier also calculated the three following economic metrics, in-line with previous evaluations:

1. Cost of Saved Energy (includes DR) ($/kWh) = $0.0500
2. Reduction in Revenue Requirements (includes DR) = $94,261,200
3. Benefit-Cost Ratio = 1.86

The net program impacts and results of the benefit-cost tests are provided in the following table.

Table 7-1: FY 2017 Net Energy and Demand Savings

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Net Present Value of Avoided Cost Benefits	Rebate $	Admin and Marketing $	Total Program $	PACT
Energy Efficiency Programs										
Home Efficiency	93%	2,105,647	964	2,012	806	$2,482,849	$677,978	$21,245	$699,223	3.55
Residential HVAC	95%	11,816,563	5,140	5,277	4,449	$12,048,903	$4,070,510	$106,443	$4,176,953	2.88
New Homes Construction	100%	440,324	256	379	308	$738,409	$468,832	$12,127	$480,959	1.54
Refrigerators	63%	212,893	28	32	29	$64,445	$56,570	$8,171	$64,741	1.00
Residential Lighting (LED)	85%	87,354	9	43	14	$53,104	$63,647	$3,404	$67,051	0.79
Weatherization	100%	15,211,611	7,279	15,661	6,936	$18,575,855	$18,005,102	$2,125,699	$20,130,801	0.92
Home Energy Assessment	84%	1,584,885	142	627	199	$777,672	$944,227	$16,354	$960,581	0.81
MultiFamily Energy Efficiency	92%	1,011,265	85	341	108	$427,768	$352,793	$6,110	$358,903	1.19
School2Home	95%	1,265,003	100	383	119	$478,303	$547,602	$9,485	$557,087	0.86
Residential Retail Partners	77%	1,263,511	127	628	199	$768,101	$321,825	$5,574	$327,399	2.35
Residential Subtotal		34,999,056	14,129	25,382	13,167	$36,415,409	$25,509,086	$2,314,612	$27,823,698	1.31
Commercial Large Lighting	85%	116,062,320	19,240	21,230	19,151	$61,871,151	$18,192,066	$636,929	$18,828,995	3.29
Commercial HVAC	96%	10,428,666	2,715	2,856	2,614	$9,878,521	$3,894,956	$147,008	$4,041,964	2.44
Commercial Custom	100%	7,678,459	391	513	354	$1,921,274	$664,742	$29,264	$694,006	2.77
Commercial New Construction	100%	8,016,167	1,159	1,183	1,133	$5,033,138	$1,061,486	$30,462	$1,091,948	4.61
C&I Solutions	85%	1,536,628	337	390	335	$935,881	$923,734	$17,671	$941,405	0.99
Schools & Institutions	100%	0	0	0	0	$0	$628,549	$12,024	$640,573	0.00
Small Business Solutions	85%	324,767	13	82	13	$119,109	$411,674	$7,875	$419,549	0.28
Whole Building Optimization	100%	0	0	0	0	$0	$155,089	$2,967	$158,056	0.00
Commercial Subtotal		144,047,006	23,856	26,255	23,600	$79,759,074	$25,932,297	$884,200	$26,816,497	2.97
Energy Efficiency Subtotal		179,046,063	37,986	51,637	36,767	$116,174,483	$51,441,383	$3,198,812	$54,640,195	2.13

Table continues on next page.

Program	Net-to-Gross Ratio	Net Energy Savings (kWh)	Net Coincident Peak Demand Savings (kW)	Net Non-Coincident Demand Savings (kW)	Net ERCOT 4CP Demand Savings (kW)	Net Present Value of Avoided Cost Benefits	Rebate $	Admin and Marketing $	Total Program $	PACT
Demand Response Programs*										
Commercial Demand Response	100%	2,625,434	81,507	97,039	66,121	$11,991,960	$4,700,074	$167,113	$4,867,187	2.46
Auto Demand Response	100%	149,111	6,189	7,290	5,633	$1,904,951	$1,286,639	$52,868	$1,339,507	1.52
Smart Thermostat	100%	740,707	34,757	43,863	30,041	$4,619,175	$3,966,166	$168,578	$4,134,744	1.72
Home Manager	100%	504,961	40,170	45,703	36,235	$2,971,952	$3,340,585	$193,131	$3,533,717	1.51
Bring Your Own Thermostat	100%	3,653,236	10,928	13,197	10,441	$7,213,487	$963,456	$118,104	$1,081,560	3.05
Demand Response Subtotal		**7,673,449**	**173,550**	**207,091**	**148,471**	**$29,428,485**	**$14,256,920**	**$699,794**	**$14,956,714**	**2.20**
Renewable Energy Programs										
Solar Initiative - Residential	100%	47,800,667	13,741	28,328	12,367	$53,706,008	$35,345,295	$1,442,717	$36,788,012	1.46
Solar Initiative - Commercial & Schools	100%	3,638,996	1,094	2,164	953	$4,167,386	$3,125,011	$128,431	$3,253,442	1.28
SolarHostSA Pilot**	100%	1,984,985	571	1,176	514	$131,403	$0	$78,323	$78,323	0.50
Roofless Solar Pilot	100%	2,159,271	576	1,133	0	$1,785,823	$1,289,375	$126,326	$1,415,701	0.83
Renewable Energy Subtotal		**55,583,919**	**15,982**	**32,802**	**13,834**	**$59,790,620**	**$39,759,682**	**$1,775,797**	**$41,535,479**	**1.41**
Grand Total		**242,303,430**	**227,518**	**291,530**	**199,072**	**$205,393,588**	**$105,457,985**	**$5,674,403**	**$111,132,387**	**1.86**

* The PACT for Demand Response Programs is calculated based on the net present value of avoided cost benefits divided by the net present value of program costs *attributable to new, incremental participants during the program year.* Because total program costs in the table represent the costs attributable to all participants, the PACT for Demand Response Programs cannot be directly calculated from data presented in the table.

** In calculating the PACT for the SolarHostSA Pilot program, Frontier considered bill credits paid to host site customers as incentives. This differs from CPS Energy's accounting, which shows $0 in rebates paid to customers. Thus, the PACT for the SolarHostSA Pilot program cannot be directly calculated from the data presented in the table.

Table notes:

- Net savings = gross savings * Net to Gross ratio / (1 – line loss factor).
- DR program net energy and demand savings (in lighter shade) represent end of year program capability, based on end of year enrollment
- All residential and commercial energy efficiency programs were involved in a transition during FY 2017, transitioning to a different implementer, shutting down, or starting up during the year. Savings and benefit cost calculations should be interpreted in the context of these transitions.

7.2 EMISSIONS REDUCTION

Emission reductions are based on annual energy savings, those attributable to the gross number of new participants in each program in the current year.

Table 7-2: Emissions Reduction Impacts by Program (lbs.)

Program	CO2	NOx	SO2	TSP
Home Efficiency	1,937,195	863	1,284	80
Residential HVAC	10,871,238	4,845	7,208	449
New Homes Construction	405,098	181	269	17
Refrigerators	195,862	87	130	8
Residential Lighting (LED)	80,366	36	53	3
Weatherization	13,994,682	6,237	9,279	578
Home Energy Assessment	1,458,094	650	967	60
MultiFamily Energy Efficiency	930,363	415	617	38
School2Home	1,163,803	519	772	48
Residential Retail Partners	1,162,430	518	771	48
Residential Subtotal	**32,199,132**	**14,350**	**21,349**	**1,330**
Commercial Large Lighting	106,777,334	47,586	70,798	4,410
Commercial HVAC	9,594,373	4,276	6,361	396
Commercial Custom	7,064,182	3,148	4,684	292
Commercial New Construction	7,374,874	3,287	4,890	305
C&I Solutions	1,413,698	630	937	58
Schools & Institutions	0	0	0	0
Small Business Solutions	298,785	133	198	12
Whole Building Optimization	0	0	0	0
Commercial Subtotal	**132,523,246**	**59,059**	**87,869**	**5,474**
Commercial Demand Response	2,415,399	1,076	1,602	100
Auto Demand Response	29,296	13	19	1
Smart Thermostat	89,222	40	59	4
Home Manager	28,546	13	19	1
Bring Your Own Thermostat	1,738,370	775	1,153	72
Demand Response Subtotal	**4,300,833**	**1,917**	**2,852**	**178**
Solar Initiative - Residential	43,976,614	775	1,153	72
Solar Initiative - Commercial & Schools	3,347,876	19,598	29,158	1,816
SolarHostSA Pilot	1,826,186	1,492	2,220	138
Roofless Solar Pilot	1,986,529	814	1,211	75
Renewable Energy Subtotal	**51,137,205**	**22,679**	**33,742**	**2,102**
Grand Total	**220,160,416**	**98,004**	**145,811**	**9,083**

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